DISCUSSION OF CONFERENCE PAPERS

(Part One)

Contents

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REA

U. S. DEPARTMENT OF AGRICULTURE

RURAL ELECTRIFICATION ADMINISTRATION

ABOUT THE CONFERENCE .... The purpose of the Annual Conference for REA Field Engineers is to provide a forum for the discussion of engineering matters concerned with rural electric systems. The objective is to make available to field engineers an opportunity to share views and experience with other engineers who have developed a high degree of experience and specialization in specific fields. Likewise, the objective is to provide the specialist engineer with an opportunity to share his views with those who are facing the practical daily engineering problems.

To assure freedom for the development of ideas which may serve to improve the engineering of rural electric systems, the authors of papers and discussions have been encouraged to explore new ideas and new techniques and to prepare papers which reflect their own engineering judgment and experience. Such an approach may develop ideas which deviate from industry practices and REA policies and procedures presently in effect. It should be recognized, however, that REA policies and procedures as set forth in REA bulletins are still applicable unless changed in the light of the ideas and experience which may result from such papers or discussions.

R G Zook

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Assistant Administrator

ECONOMIC DESIGN OF PRIMARY LINES FOR RURAL DISTRIBUTION SYSTEMS

Discussion and author's closure of paper by Roland W. Schlie

Harry W. Thiesfeld (REA Field Engineer, Mankato, Minnesota): We believe that Mr. Schlie's paper is a good new mathematical application of a concept to the economic choice of distribution circuits. Considered in this light and in mathematical terms only we believe that one can offer little constructive criticism, but recommend it as a very useful aid to engineering judgement. However, we, as a committee do consider the conclusions a little too stringent and perhaps should be modified somewhat by further consideration of pertinent factors.

Each member of the panel will submit his own written discussion, but, for a general coordination of comments the following general areas will be respectively discussed:

Mr. Lundeen - "Some Other Practical Considerations"
Mr. Phillips - "Some Practical Limitations in Application"
Mr. Thiesfeld - "Professional Comments and Consideration of factors 'A' & 'C'."

PROFESSIONAL COMMENT

Upon presenting the paper to a Professional Engineer for his evaluation, he, after a brief perusal, offered this paraphrased comment, "IT looks like Mr. Schlie has given this some good academic treatment and doubtless has some notable contribution, but," he emphasized, "so long as REA recognizes, approves, and even seemingly encourages, line design by managers and linemen who apply no technical or economic analysis, I am not going to waste my time or yours by trying to study it. It will not be used."

Another Professional Engineer was more sympathetic but did draw about the same conclusions with the added observation that if REA published the paper per se it might be used for conclusions by inexperienced and less qualified people in lieu of experienced engineering judgement.

CONSTANTS AND FACTORS

It is suggested that the constants used in APPENDIX IV be the National averages as nearly as practical, although it is recognized that they are selected only in support of a mathematical illustration.

Factor "C = Cost per mile of line expressed in $ per mile." pp 5, APPENDIX I.

The explanation following this should be further clarified. This is suggested:

> The cost of transformers, secondary services, meters and all secondary circuit investments should be excluded. This includes the cost of poles, conductor, ground, sectionalizing devices, and applicable engineering and O/H expenses. Right-of-way should be included if separate or new route is selected.

Factor "A = Annual fixed rate expressed as a decimal." pp5, APPENDIX I.

It should be pointed out that this factor may vary considerably. Depending upon management policies, rate of growth of the load, physical condition of the plant, state requirements, etc. this factor may vary within the following probable limits:

	Low	High
Operations ----------------------------	0.75%	1.5%
Maintenance ---------------------------	0.75%	1.5%
Insurance and Taxes -------------------	0.25%	1.0%
Depreciation*--------------------------	2.00%	5.0%
Amortization** ------------------------	1.00%	3.3%
Interest ------------------------------	0.50%	1.2%
	5.25%	13.5%

* Actual depreciation may vary within these limits, or more, depending upon rate of load growth, obsolescence, caliber of construction, quality of materials used, weather and climatic impositions, source of power, etc. Also management policy will dictate whether funds for replacement (in kind and/or of higher capacity) should accrue from "depreciation" or be secured from outside financing.

** Amortization (and interest) costs will vary depending upon the percentage of local capital used in plant. Since cash must be provided for out of earnings, the cost of amortization should be considered in evaluating property investments under the REA type financing. The financial costs of invested capital will depend upon management policy and hence "amortization" (or dividends in the case of private capital) and "depreciation" must, in a measure, be considered together.

While the above table shows wide variance in range it is the writer's opinion that the upper or higher value of the constant should be used in most cases. Some analysis of systems indicate that 10% to 12% is a better suggested figure than 7%, particularly when the portion of the system that we are primarily dealing with in relation to conversion or "heavying up" are those portions that will have a high obsolescence rate.

Further study is suggested with reference to cost losses with respect to time that might accrue should it be a temptation to choose say the next most economical size and phase when that combination may be of a short duration. For example, it may show under a particular set of circumstances that it was economical to go from 1Ø #4.7/1 to 3Ø #2.6/1. How much cost would accrue and when will it be a "break even" time if one selected 3Ø # 1/0-.6/1?

It has been a pleasure to work on this and commendation is due the author.

Nelo L. Lundeen (REA Field Engineer, Decatur, Illinois): The application of voltage regulators within their practical limits of operation is questionable. Power supply by utilities under present day conditions is such as to require their installation at substations to hold the voltage within reasonable limits on the outgoing feeders

because of the voltage swing on the utilities' power supply, many of which are entirely unregulated. However, if line regulators are to be designed into a distribution system study, certain limitations will be imposed upon that system such as:

(a) Lack of system flexibility in respect to unanticipated large power loads.

(b) If voltage regulator failure is experienced at any time, very unfavorable operating conditions will occur. This will require more frequent and adequate testing and maintenance programs to keep voltage regulator failures at a minimum.

(c) Several spare units needed for replacement in case of failures. This represents added investment which could be applied to economical conductor installation.

It appears that the use of line regulators designed in a system study would definitely lower the quality of service rendered and, therefore, should be avoided as a permanent part of a system design, or at least limited to some value less than the full 10 percent boost application. In system design more emphasis should be placed on additional substations as this design generally will permit economical use of existing conductor sizes as well as provide better quality of service.

Line regulators can definitely be employed to economic advantages in system design on both single and three phase feeder lines to:

(a) Defer system improvement construction until it is necessary. In certain cases this deferment permits additional time for load development thus allowing a more economical conductor selection.

(b) Carry certain short period loads such as oil pumping and recovery program which in most cases are a 10 year program. This results in a considerable savings in increased conductor investment which would have no further use when oil pumping is curtailed.

If line regulators become a permanent part of a system design, borrowers should provide adequate inspection and servicing at short intervals to render a good quality of service.

SYSTEM IMPROVEMENTS

In various system study designs, a sequence of system improvements is often established that converts a single phase line to a V phase line and at some subsequent year is again converted from V phase to three phase line. These recommendations were often followed until many borrowers observed that a very short period of time existed between the two recommended conversions. Consequently, borrowers omitted the intermediate conversion step and performed the conversion recommended in the final sequence for the particular line in question. This procedure does account for an increased investment a few years in advance. However, this increased investment is more than offset by the savings in labor and in continuity of service when the intermediate step of conversion is omitted. The labor costs of conversion from single to three phase are very little more than those when converting single to V phase. This is also true in regard to

equipment charges on this construction. The additional investment is represented in the single conductor. With line conversion made directly from single to three phase, construction crews are made available for other system improvement requirements, or can be made available for operations and maintenance duties.

The extensive use of V phase lines should be discouraged for both conversion and new construction. This conclusion has been verified through experience of many systems. The possibilities of three phase loads do exist and they can be more readily served than from a V phase line which may require conversion to three phase at an additional cost. In the design of feeders, however, it is often necessary to employ V phase lines for short distances to provide adequate load balance.

To avoid large uneconomical conductor sizes which often occur when reduced voltage drops are desired, feeder lines should be shortened by adding new substations. This often may require transmission lines so that substation can be located at load centers. The additional transmission line cost is justifiable with its short distribution feeders of smaller conductor as compared with a substation and long distribution feeders and large uneconomical conductor sizes. In the latter case construction costs may be considerably less than that when a transmission line is needed for a new power supply. However, with adequate sources of supply for new substation the problems of system load growth can be adequately met and in the long run will be more economical. In this respect it may be desired to standardize not only in economical conductor sizes but also in substation capacity at proper locations. In this respect a system of approximately 3,250 miles of distribution line has standardized on substation capacities of not larger than 1500 KVA and conductor sizes not in excess of No. 2 copper equivalent. Numerous large power applicants are served and new applications received which have required new substations in accordance with the area loads to be served.

The addition of new substations may tend to lower the system load factor especially where small industrial loads such as gravel or agricultural lime pits are involved. The location of the new substation could remove some of this load from an existing substation in such a manner as to reduce a good load factor that can be derived from a high diversity factor. If the area of the new substation is basically of the same type of farming, then no appreciable effect upon load factor would be noted. These factors should also be considered in light of the power suppliers policy with respect to cost of transmission.

James H. Phillips (REA Field Engineer, Jacksonville, Florida): The paper prepared by Mr. R. W. Schlie represents an important contribution to the study of conductor economy. He has undertaken a new approach to the subject and has derived a sound mathematical solution applicable to both new and conversion lines. The logic employed in the derivation of the various formulae is unassailable and the result is a straightforward method for comparative economic analysis of new line conductivities, or proposed changes in conductivities of existing lines.

The purpose of this discussion is to consider the variable factors employed by Mr. Schlie in the development of formula constants, and the effect of these variables on results obtained from this method of analysis. Furthermore, suggestions of additional factors relating to economy are included for the author's consideration.

GENERAL

In order to evaluate Mr. Schlie's paper, it should be noted first that conclusions drawn by Mr. Schlie are related directly to assumed factors of wholesale power cost, operations and maintenance expense, load and demand factors, cost of new and conversion line construction, etc. It is in order to discuss these factors and their relationship to conductor economy in the analysis procedure developed by Mr. Schlie.

Fixed Charge Rate (Constant A)

The fixed charge rate of .07 appears somewhat high for uniform application. Furthermore, since the fixed charge rate includes operations and maintenance expense as well as other items such as interest and depreciation which may be considered as variables, it appears that applicable fixed charge rates should be determined for the particular lines under consideration. For example, express feeders where applicable as proposed by Mr. Schlie would likely be routed "cross country," and higher operations and maintenance expenses would be anticipated.

Further study of operations and maintenance expense relationships to line locations and types of conductor appear to be warranted. Adjustment of the fixed charge rate constant would have a direct bearing on results of the economy study.

Demand and Energy Charges (Constants M and L)

The assumed constants of $1.61 per KW demand plus an energy charge of $.013 per KWH, used for illustrative purposes by Mr. Schlie, represent unusual and extremely high cost power. At a load factor of 50%, the average cost per KWH would be 17.41 mills. There are few places in the country today where such power costs prevail. The latest yearly report I have available for national average cost of power purchased by REA borrowers is dated June 30, 1951. This report indicates that in the prior year, the national average cost per KWH furnished by power companies was 8.9 mills; and for power supplied to borrowers by publicly owned suppliers, 5.9 mills. No doubt similar cost figures would be lower at the present time.

These demand and energy constants directly affect the value of Loss Constant (J), and additional comments are included later in this discussion.

Load Factor (Constant LF)

Load factor has a direct bearing on results on an economy analysis, and it appears that its effect on Loss Constant (J) should be set forth more fully. Using REA Demand Tables, the load factor, for example, of a 130 KW load would be 30 to 32 percent. For a load of 400 to 600 KW, the load factor would be 40 to 43 percent. A practical suggestion would appear to be to determine Loss Constants for various ranges of KW loading from which families of equation constants could be derived for the application of equation 13.

Demand Factor (Constant N)

Mr. Schlie's recognition of the fact that demand varies month by month is good. However, loss demand varies with the square of system demand and therefore it appears that Constant (N) should be the square of the ratio of average to peak

monthly demands. The resulting Loss Constant (J) in Mr. Schlie's calculations would be .0382 instead of .04. The effect of squaring the ratio is minimum where high ratios of average to peak demands obtain. The effect on lower ratios is more readily apparent.

Power Factor (cos θ)

The applicable power factor does not appear to be clearly defined. Since the economy analysis is made on the basis of annual cost, the effect of variations in power factor should perhaps be explored.

New and Conversion Line Costs (Constant C)

In an analysis of conductor economy, the cost of new and conversion lines must be estimated for the particular area and loading involved. This is an entirely obvious statement, but is included in order to illustrate economy problems in areas where low cost wholesale power plus reasonable construction costs prevail. The following cost table for new and conversion lines in medium loading was obtained from one of the larger engineering firms in the Southeast Area:

Construction Costs for New ACSR Lines, Medium Loading Area

ACSR	1ø	"V"ø	3ø
4	1100	1480	1720
2	1170	1610	1930
1/0	1280	1830	2260
2/0		2000	2580
3/0			2970

Conversion Costs, ACSR Lines, Medium Loading

Existing	Convert To: 1ø		"V"ø				3ø				
ACSR	#2	1/0	#4	#2	1/0	2/0	#4	#2	1/0	2/0	3/0
1ø 4/4	330	450	760	1030	1250	1660	980	1320	1650	2130	2510
1ø 2/4		420		820	1230	1450		1100	1620	2060	2490
1ø 1/0/4					940				1330	1930	2200
Vø 4/4				560	780		490	960	1290	1800	
Vø 2/4					730			560	1250	1580	2130
Vø 1/0/4									670		
3ø 4/4								800	1130	1725	2100
3ø 2/4									1070	1480	2030

Many of the above estimated costs differ considerably from cost estimates employed by Mr. Schlie, yet the above costs must be presumed approximately correct for some borrowers in the Southeast Area. It is not the intent of this discussion to compare accuracy of cost information, but only to illustrate the effect of cost data for a particular area, since in the final analysis the results of an economy study will be directly effected by factors pertaining to the particular

area involved. The effect on an economy analysis of different, and in many instances much lower, construction cost plus applicable changes in other constants will be given later in this discussion.

Loss Constant (J)

In order to illustrate the effect of much lower wholesale power cost in an economy analysis, the following calculation of Loss Constant (J) is made using present power cost in the service area of a Southeast Area power supplier (Georgia Power Company).

Demand Charge (M)	0
Energy Charge (L)	6.5 mills/KWH
Load Factor (LF)	.40 (assumed)
Loss Factor (J) =	$.012MN + 8.76LH$
=	$0 + 8.76(.0065)[.84(.40)^2 + .16(.40)]$
=	$0 + .05694(.1984)$
=	$.0113$

The effect of this lower Loss Factor would be an 89% increase in KW in the group of equations developed by Mr. Schlie from equation #13 for comparison of lines.

Table III and Table VI

Using construction cost estimates obtained from an engineering firm (as given on page 3 of this discussion) and a Loss Constant (J) of .0113 as developed for a particular supplier, the following comparison with results obtained by Mr. Schlie is made for new and conversion lines, Tables III and VI.

Table III
Comparison of New Lines

Line Comparison	Equal Cost Load	Adjusted Equal Cost Load
1Ø4 or 1Ø2	125 KW	152 KW
1Ø4 or VØ4	159	282
1Ø4 or VØ2	176	382
1Ø4 or 3Ø4	176	312
1Ø4 or 3Ø2	152	334
1Ø2 or 1Ø1/0	221	220
1Ø2 or VØ4	206	426

(Complete comparison not made. Sufficient values calculated for illustrative purposes.)

Table VI
Economic Conversion Loads

Conversion	Wire Size	*E.C.L.	**A.E.C.L.	*** V.D. per Mi. A.E.C.L.
1Ø to VØ	4 to 4	183 KW	399 KW	1.33%
1Ø to VØ	4 to 2	242	405	.98%
1Ø to VØ	4 to 1/0	278	410	.73%
1Ø to 3Ø	4 to 4	187	392	.69%
1Ø to 3Ø	4 to 2	241	424	.51%
1Ø to 3Ø	4 to 1/0	284	443	.372%

(Complete comparison not made. Sufficient values calculated for illustrative purposes.)

* Economic Conversion Load.
**Adjusted Economic Conversion Load.
***Voltage drop per mile, adjusted economic conversion load.

The effect on system design of the adjusted KW values in Tables III and VI is immediately apparent. Voltage drop considerations become of increasing importance on the larger capacity lines of Table III. With reference to Table VI, the adjusted KW values and related voltage drops per mile indicate that conversion often must be accomplished prior to reaching desired economic conversion loads. Since the value of Loss Constant (J) is a predominant factor in results obtained, it is apparent that the problem of obtaining economic loading of conductor is considerably magnified in areas having relatively low cost wholesale power. The national average cost of power supplied to borrowers would appear to confirm this problem of economic loading as being widespread indeed.

CONCLUSIONS

1. The problem of economic conductor loading in prevailing widespread areas of relatively low wholesale power cost to borrowers appears not fully appreciated. It is suggested that illustrative examples should have included power costs more closely approaching national average power costs.

2. The inference is plain that considerations other than economy often influence the selection of phasing and conductivity of both new and conversion lines - for example, voltage drop or load balance, or a combination of the two.

   The magnitude of the conversion economy problem is indicated by the fact that the ratio of conversion mileage to new line mileage in current System Studies is on the order of 5 to 7 to 1.

3. Cost of new and conversion line construction should be determined with considerable care for the particular area and loading involved. In the cost figures used for illustrative purposes by Mr. Schlie for conversion of a 3Ø #4 ACSR line to 3Ø #1/0 ACSR line, today's replacement cost is used for the #4 ACSR line, plus conversion cost to arrive at a total cost of conversion. It appears incorrect to apply present day replacement costs in such a manner to lines presumed to be several years old in most instances.

4. Yearly Demand Factor (Constant N) should be the square of the ratio of average to peak monthly demands.

5. It appears that rather broad conclusions are reached through rather limited consideration of specific conversion problems. This does not imply a fault of the method of economy analysis, but more caution probably should be used in evaluating the results of the analysis.

   For example, in lieu of conversion involving a change in conductor size, an inference is drawn to indicate that express feeders, parallel feeders, or new sources of supply should be recommended on the basis of economy. Actually, such determinations usually can be made only on the basis of an expanded cost

analysis of line changes required in the entire area under consideration. Such line changes in an entire area may be anticipated to involve several types of conversion.

Express or parallel feeders result directly in the maintenance of two lines instead of one; and express feeders may be anticipated to be routed "cross country" with resulting higher operations and maintenance expenses. Both express and parallel feeders now may be anticipated to involve R/W acquisition problems, and R/W acquisition problems have been found to be very real in a considerable number of instances.

New substations now cost a minimum of about $ 30,000.00 and it appears that the magnitude of such costs has been largely overlooked. Furthermore, both conversion and tie lines are usually necessary to integrate a new source into a system.

In view of the above considerations, an expanded cost analysis usually is necessary for comparative purposes for two or more designs for system improvement. Overall system economy is the desired result, regardless of specific instances of conversion economy.

6. Conductor economy theory can only assist the system engineer in his endeavor to apply sound engineering judgment. It should be used as a guide only - not as a final arbiter of design.

In addition to considerations relating to the above conclusions, there are others bearing on economy of system design which probably should be included in an overall analysis of proposed system changes. Some of these additional suggested considerations are as follows:

7. Some power suppliers are requiring borrowers to make every effort to carry increased system loads by means of line conversion, voltage regulators, conversion to higher distribution voltage, etc., up to an overall improvement cost equivalent to alternative new power supplier transmission cost to serve new sources. In some areas, the comparative cost includes both transmission and substations furnished by the supplier. Unfortunately, in some instances, power suppliers have used cost estimates for providing new sources far above REA cost records or estimates for similar construction, and this has resulted in economic hardships for the effected borrowers.

8. Higher cost per KWH on new sources in the above minimum KWH cost brackets of wholesale power contracts.

9. Loss of diversity resulting from new sources, with consequent increased demand charges.

10. Voltage regulator losses.

11. Conversion to higher distribution voltage.

12. Most systems have practically reached area coverage, resulting in a consequent reduction in latitude for economic design of new feeder systems.

13. Increased salvage value of obsolete size conductor - particularly copper conductor which now in many instances is worth as salvage very close to original installed cost. ACSR conversion of copper lines has become widespread due to the much more favorable net cost of conversion.

14. In proposed conversion of single phase and "V" phase lines in System Studies prepared by some System Engineers, REA has approved for many years the addition of conductors having greater conductivity than existing conductors which are left in place - for example, the addition of 2 - #2 ACSR conductors to a single phase #4 ACSR line. The economic aspects of this as compared to also replacing the #4 ACSR phase conductor with #2 ACSR indicate this to be an excellent practice.

    Furthermore, our voltage drop calculation procedure includes consideration of unbalanced systems.

    No undue operating or maintenance problem has been reported by borrowers having unlike conductivity multiphase lines. It appears that the economic merits of this type of conversion should be recognized.

15. It appears that consideration should be given in economy comparisons to the effect of conductivity or multiphasing as the case may be to revenue loss due to voltage drop. The General Electric Company, Westinghouse, Allis-Chalmers and perhaps other companies have made investigations of such revenue losses and it appears that this subject is deserving of considerable study.

    REA has not recognized the effect of voltage drop on revenue, but there is considerable evidence - including the operating experience of some borrowers seeking information on this subject - that a definite revenue-voltage drop relationship does exist. It would appear to be an entirely valid consideration for System Engineers to apply in economy studies, and some System Engineers have applied this factor in economy studies for some time. The objective would be of course the determination of NET gain from increased KWH resulting from reduction of voltage drop.

As a final comment on this paper, it should be noted studies such as this proposed by Mr. Schlie have very limited application among REA borrowers. System Engineers will of course follow recommended procedures in System Study design work. However, subsequent to the preparation of a System Study, needs for unanticipated line changes may arise because of new loads or growth trends varying from trends used as the basis of design. Borrowers generally do not employ on their own payrolls qualified engineers who understand and can apply economic principles in line construction.

Mr. Schlie has performed an excellent service for distribution engineers in the preparation of this paper. However, until such time as borrowers recognize the need and initiate action to obtain employee engineers, effort such as is represented by this paper will have very limited application and will be little appreciated by those whom REA most desires to assist toward improved economic practices.

Walter Castle (Castle Engineering Company, Dayton, Ohio): Thank you for the opportunity to review the paper regarding "Economic Design of Primary Lines for Rural Distribution Systems" prepared by Mr. Roland W. Schlie. It is certainly every distribution engineer's hope that a formula can be evolved which will allow him to select a given line design for any particular loading anticipated and to implement planned changes in design by measurement of experienced demand, Mr. Schlie's approach to this problem represents constructive thinking in this matter.

Any method of line design inevitably requires assumptions as to future loadings and future methods of development. In the case of the subject paper, future system loads have been projected over a period of thirty-five years and methods of line development assumed (See Figure 8 and 9), resulting in future RMS loading of 2.38 times present demand. While these assumptions may be proper from a system standpoint, the writer questions the propriety of assuming these methods of development for individual distribution lines.

The use of voltage regulators, as indicated in Figures 8 and 9, and the establishing of new sources, as indicated in Figure 9, both entail costs in installation, maintenance and operation which should be considered in conjunction with conductor losses to determine the lowest over-all cost. On many feeders, it will be physically impractical to follow the assumed method of development. Furthermore, in assuming continued load growth for extended periods, it is presumable that under many conditions consideration must be given to utilization of higher distribution voltages. For the above reasons, it appears that the design loadings used are subject to question.

The author of the subject paper appears to feel that present design procedures are resulting in the installation of conductors of greater capacity than economically justified. The writer does not feel that this is a general condition in the area with which he is familiar, although it may well be true under other conditions.

The writer feels that continued load growth, and the very existence of the system, is contingent to a great extent on the quality of service rendered, and that in the design of a distribution system adequate voltage control must be conceded as the paramount consideration rather than economic design.

Roland W. Schlie: The comprehensive discussions presented during the Technical Conference are encouraging. They demonstrate a true interest in the subject. The discussions on this paper were reviewed in great detail. The author's primary objective in this detailed review was to determine whether or not the procedure of economic analysis and the conclusions drawn from the analysis are sound.

Discussions on this paper bring up many points which are in agreement with the paper or which were not presented as a challenge to the procedure or conclusions. These are not discussed further. Some points are covered only in a general manner. Those points which directly dispute the procedure and conclusions are discussed in more detail.

It should be noted that the subject paper concerns the economic design of primary lines. Several comments give the impression that the paper has been judged in that it does not automatically solve the problem of obtaining an economic design

of a distribution system. A study of the economic design of a distribution system includes more than the economic design of primary lines. Actually, economic system design often dictates less than the most economic design of particular primary lines. However, this paper should prove to be a practical engineering guide in arriving at the economic design of a distribution system.

Voltage standards have been determined for REA primary lines. These standards must be met in the design and in the operation of the system. The standards are: 127 volts maximum and 116 volts minimum (referred to a 120-volt base) for primary lines. These limits are not based upon economic considerations but solely on service requirements of the system. An economic design of a distribution system is one which meets this standard (as well as all other design standards) and results in the lowest annual cost. Voltage standards can be met by choice of conductor size, number of phases, length of circuits, primary voltage level and using voltage regulators. Before a less economical conductor size is recommended it should be determined that other means of meeting the voltage standards prove more costly than the selection of a less economical conductor size. It is not sufficient to state that a circuit has excessive voltage drop if the economical conductor size is used and therefore a larger size is recommended. Rather, economic system design requires that other means of reducing voltage drop (number of phases, length of circuits, primary voltage level and using voltage regulators) must be evaluated to determine that increased conductor size results in lowest annual cost.

With reference to distribution line load growth, it is stated in the paper that preliminary studies indicate that the two developments of feeder capacity as illustrated in Figures 8 and 9 are the most economical. Additional studies have been made which result in further evidence to substantiate this statement. Economic studies are not precise. The value of 2.38 times present loading is a justified approximation in light of the relative accuracies of other values used in an economic study.

It was stated that conclusions drawn are related directly to assumed factors of wholesale power cost, operations and maintenance expense, load and demand factors, cost of new and conversion line construction, etc. It should be noted that the same conclusions are justified when each assumed constant used in the paper is changed. An analysis of completed calculations given in the discussion will verify this. Costs of new and conversion construction are critical. The costs shown in the discussion are proportionate to those given in the paper and therefore change the magnitude of the loading limits without appreciably changing the relative loading of one line compared to another. Constants are chosen to match existing conditions for a specified system (except the value "A"). They could conceivably be modified for each line but it is doubtful that such a refinement could be justified.

The value "A", fixed charge rate, is assumed constant for all systems. The author believes this to be justified in view of his analysis of economic studies in which this value was assumed to be a variable. In too many instances the fixed charge rate appeared to be chosen in an effort to support either higher or lower loading limits and thereby justify rather extreme recommendations. The author is not confident that a value of .07 should be assumed for "A", rather that some fixed value be recommended. In the discussions it is implied that this value will vary from 5.25 to 13.5 percent. This range was established by adding all minimum or maximum values of each charge included in the fixed charge rate. It is very

doubtful that the range can be established in this manner for it would be under rare circumstances that all values would be either a maximum or a minimum. The author would estimate a range of 7 to 10 percent to be more accurate.

The factor "N", yearly demand factor, was included in equation (3) to more accurately express the cost of demand resulting from losses. The value of "I" used in this equation is the RMS value of future yearly peaks. Since demand charges are actually monthly charges, it was necessary to correctly evaluate the cost of demand resulting from losses by using the constant 12 and the factor "N". As used in this equation "N" is defined as the average monthly KW demand divided by the peak monthly demand. As pointed out in the discussion, "N" is more accurately defined as the ratio squared of average monthly KW demand divided by the peak monthly KW demand. Where a yearly ratchet clause applies, some modification of the value "N" must be made.

SERVICE TO LARGE MOTOR LOADS

Discussion and author's closure
of paper by Harold W. Kelley.

R. C. Holland(REA Field Engineer, Denver, Colorado): I have no comments on the paper prepared by Mr. Kelley entitled "Service to Large Motor Loads", however, I have observed some installations to serve large motors and will comment on this phase briefly.

One borrower had a request for 300 kva to serve a 350 hp motor which operated at 2300 volts, 3600 rpm. This installation was located some 42 miles from the substation on a 14.4/24.9kv system.

In trying to start this motor and pump it was found that the motor would not get up to rated speed. The best they were able to do was get the motor up to 1800 rpm and this would draw 350 amperes per phase to the motor. By disconnecting the pump the motor would reach rated speed in a short while and under this condition it required 310 amperes per phase.

To make this installation operate the borrower installed a spare 1500 kva transformer bank and the pipe line company installed a motor operated valve that would shut the discharge off until the motor almost reached rated speed and then the valve would start opening and open on rated speed and thus prevent damage to the pump. This particular installation is now all automatic and is controlled from a town about 100 miles away.

At another installation a borrower installed two 350 hp 2300 volt 3600 rpm motors some 40 miles from the substation on a 14.4/24.9 kv system. This installation has given trouble and at the present time is not in operation. They had to start the motors under no load and when they tried to start the second motor the first one would drop off the line. To correct this they connected a regulator in the circuit that would boost the voltage after they had the first one started. The manager states they have had experiences with other motors and that the slower speed motors do not give the starting troubles that these high speed motors do.

VOLTAGE FLICKER

Voltage flicker at one borrower is present on an infrequent basis due to the large motor starting and after the borrower explained to the consumers along the line they quit complaining.

MOTOR PROTECTION

The irrigation borrowers in my area require three element protection for the motors but I do not know of any that require phase reversal protection. We had one case of damage due to phase reversal and this was caused by the three-phase line being wrapped together and when the borrower closed in the breakers in trying to get the line on they caused reversal on a two-phase line and had two pumps damaged.

PHASE CONVERTERS

There are a number of these phase converters in operation and they apparently give satisfactory service especially on oil well pumping. A couple of years ago, I had a request to check a 15 hp installation that would not start. In this instance it was found that this was a motor and pump installed down a well some 250 feet with small leads, and further, the transformer was some 300 feet from the well. This borrower's trouble was that they were unable to figure the voltage drop in the secondary. When we moved the transformer to the well the motor would start and it operated satisfactory as far as the borrower was concerned. The consumer, however, is paying for about 22 kw to run this 15 hp pump and motor.

C. P. Potter (Wagner Electric Corporation, St. Louis, Missouri): In this paper, Mr. Harold W. Kelley has provided a great deal of useful information, presented in a very practical way. The part of the paper dealing with phase converters is particularly timely and analyzes the various problems which are involved, in a fair and impartial manner.

Mr. Kelley refers to the desirability of having three overload elements in motor starters which are used for irrigation applications. It may be advisable to go still further and require three overload elements for all these jobs, because the majority of these applications may be ~~saved~~ served by isolated transformer banks. The note in Section 4327 of the National Electrical Code states the problem as follows:

> "In the case of distribution systems supplying wye-delta or delta-wye connected transformers (having the wye neutral point in the primary ungrounded or not connected to the circuit) the authority enforcing this code may require that three running over-current units be provided for the protection of three-phase, three-wire motors, if field experience in the territory of the authority indicates that a third unit is desirable because of motor winding failures at times of primary single phase failures, unless the motors are otherwise adequately protected".

Mr. Kelley calls attention to the possibility of nuisance trip-outs of a motor starter when exposed to direct sunlight, even though the motor may be operating at less than full load, and sufgests as one solution to this problem the use of magnetic trip elements which are not affected by ambient temperatures. This solution will reduce the number of nuisance trip-outs but may cause motor winding failures if the motor is fully loaded and is exposed to the sun. Instead of using magnetic trip elements it would be safer to use normal size thermal elements and require that neither the motor nor the motor starter are exposed to the sun or that they are both exposed to the sun. The motor-starter should certainly be subjected to the same ambient temperature as the motor.

Mr. Kelley recommends the use of reduced voltage starting when required to obtain successful operation of polyphase motors. Another method of starting these motors which should be considered is the part-winding method defined by NEMA as follows:

> "MG1-1.08.a Part-winding-start Motor
> A part-winding-start induction or synchronous motor is one arranged for starting by first energizing part of its primary (armature) winding and, subsequently, energizing

> the remainder of this winding in one or more steps. The purpose is to reduce the initial values of the starting current drawn or the starting torque developed by the motor. A standard part-winding-start induction motor is arranged so that one-half of its primary winding can be energized initially, and, subsequently, the remaining half can be energized, both halves then carry the same current".

Part-winding-starting of polyphase motors is approved by most power companies and appreciably reduces the cost of motor installations.

Harold W. Kelley: We wish to thank Mr. C. P. Potter for the preparation of the discussion and to commend Mr. F. E. Myers on his presentation and comments.

Too few electrical equipment distributors ARE aware of the danger of motor ~~borne~~ burn-out where overload elements are restricted to only two elements and service supply is from a floating wye-delta transformer bank. Distribution in rural areas should highlight this problem to purchasers of equipment and insist on supplying starting equipment with three overload elements.

We are aware of the problem of keeping motors and starters under identical ambient temperature conditions. As motors have better ventilation and are often not fully loaded, the motor failures from overheating are far less frequent than the nuisance trip-outs due to thermal de-rating of the starter overload elements. Perhaps a future development of a partially ~~amboent~~ Ambient compensated overload element will be the best compromise solution.

We are pleased to have brought to our attention the advantages of part-winding starting of induction motors. Lower cost starting equipment, simple in design, and relatively easy to install and maintain are the chief characteristics. Where a motor manufacturer offers the motor and starter as a combination, the chances of misapplication are considerably reduced. One caution must be mentioned regarding operation of part-winding-starters. Poor field inspection and maintenance can possibly result in motors being operated with one portion of the winding under single-phase power. A faulty contact on a reduced voltage starter becomes evident immediately as the entire motor is under single-phase supply with zero starting torque. A similar faulty contact on a part-winding-starter can result in a normal start with the run setting leaving the motor with three-phase on half the winding and single-phase on the other half. Normal inspection and maintenance should eliminate this possible trouble.

We wish to thank Mr. R. C. Holland for his interesting discussion. His experience with starting large motors on rural systems highlights some of the basic problems. Loss of torque due to low and unbalanced voltages is not unusual. High speed motors react to these conditions to a marked degree because the relatively lower starting torques and longer acceleration times.

A SHORT SUMMARY OF THE PROBLEMS OF NUCLEAR POWER

Discussion and author's closure of
paper by William E. Morris.

J. E. O'Brien (Chief, REA's Engineering Division): The author is to be complimented on pinpointing the principal problem areas confronting designers, manufacturers and users of nuclear power reactors. This discussion will be concerned with bringing you up-to-date on some changes which have occurred since the author's manuscript was submitted. Further revision will be made to reflect any changes that occur from this time until the Conference Proceedings are printed.

Access Agreements. (Status on January 31, 1956) The following cooperatives, or associations of cooperatives, are investigating nuclear power through access agreements with AEC:

Seminole Electric Cooperative, Inc., Madison, Florida
Corn Belt Power Cooperative, Humboldt, Iowa
Central Kansas Electric Cooperative, Inc., Great Bend, Kansas
Kansas Electric Cooperatives, Inc., Topeka, Kansas
Wolverine Electric Cooperative, Inc., Big Rapids, Michigan
Rural Cooperative Power Association, Elk River, Minnesota
Ohio Rural Electric Cooperatives, Inc., Columbus, Ohio
Cooperative Power, Inc., Piqua, Ohio
Oklahoma Statewide Electric Cooperative, Inc., Oklahoma City, Okla.
The Texas Electric Cooperatives, Inc., Austin, Texas
Wisconsin Electric Cooperative, Madison, Wisconsin
National Rural Electric Cooperative Association, Washington, D. C. (Study Group)
Plains Electric Generation and Transmission Cooperative, Inc., Albuquerque, New Mexico
Minnkota Power Cooperative, Inc., Grand Forks, North Dakota
Puerto Rico Water Resources Authority, San Juan, Puerto Rico

AEC POWER DEMONSTRATION REACTOR PROGRAM

On September 21, 1955, the AEC announced a program of demonstration reactors in the ranges of 5000--10,000 kw, 10,000--20,000 kw and 20,000--40,000 kw electrical output. This announcement called for proposals to be submitted by February 1, 1956. AEC received the following seven proposals:

1. Chugach Electric Association, Anchorage, Alaska, and Nuclear Development Corporation of America, White Plains, New York - - sodium-cooled, heavy water moderated reactor; electrical capacity, 10,000 kw; design agent, Nuclear Development Corporation; completion date, mid-1961.

2. City of Holyoke Gas and Electric Department, Holyoke, Massachusetts -- gas-cooled reactor with closed-cycle gas turbine; electrical capacity, 15,000 kw; design agent Ford Instrument Company, Long Island City, New York; completion date, not determined.

3. City of Orlando, Florida -- liquid metal fuel reactor; electrical capacity, 25,000 -- 40,000 kw; design agent and completion date, not determined.

4. City of Piqua, Ohio -- organic moderated reactor; electrical capacity, 12,500 kw; design agent, Atomics International, North American Aviation, Inc., Downey, California; completion date, 1960.

5. Rural Cooperative Power Association, Elk River, Minnesota -- boiling water reactor; electrical capacity, 22,000 kw; design agent, American Machine and Foundry, New York City; completion date, 1960.

6. University of Florida, Gainesville, Florida -- pressurized light water reactor; electrical capacity, 2,000 kw; design agent, not determined; completion date, 1959.

7. Wolverine Electric Cooperative, Hersey, Michigan -- aqueous homogeneous reactor; electrical capacity, 10,000 kw; design agent, Foster Wheeling Corporation, New York, New York, for reactor portion, and Worthington Corporation, Harrison New Jersey, for secondary loop.

Three of these proposals were submitted by REA borrowers. A fourth borrower, Golden Valley Electric Association, Fairbanks, Alaska (Alaska 6) with the Fluor Corporation, Los Angeles, California, as design agent, submitted a proposal to AEC subsequent to February 1, 1956, the closing date for proposals in the small-scale reactor program. The status of this proposal is unknown. The proposal is for the design, construction, and operation of a 10,000 kw steam plant powered by a pressurized light water reactor.

As of February 29, 1956, a Selection Board, composed of AEC staff members, is proceeding with its study and evaluation of the proposals.

REA ACTIVITIES

The REA liaison group now totals eleven members of the REA staff. Additional members of the staff participate in nuclear power matters from time to time in connection with their regular work assignments. During calendar year 1955 members of the liaison group attended 13 meetings, technical conferences and forums concerned solely with AEC matters. During the year REA became an organizational member of the Atomic Industrial Forum and, as such, has access to the great amount of resource material made available by that organization.

In September 1955 Mr. Wade M. Edmunds was appointed Special Assistant for Nuclear Power Projects in the Office of the Assistant Administrator -- Electric, and shortly thereafter enrolled in a seven-month course at the School of Nuclear Science and Engineering, Argonne National Laboratory, Lemont, Illinois.

BACKGROUND INFORMATION

Most trade journals in the electric power field contain interesting and informative articles on nuclear power developments. In addition, participants in this conference

have copies of Mr. Morris' excellent paper, and have received copies of the report entitled, "Nuclear Energy Today" which appeared in the December 1955 issue of POWER magazine. It is expected that from time to time when particularly useful information appears in pamphlet or report form, it will be made available to field engineers.

William E. Morris: A correction should be made in the text of the paper. On page 2, paragraph 3, moderators, line 3, the word not should be inserted between must and be. The entire sentence would then read: "It also must not be a neutron absorber".

Nuclear power will undoubtedly in the future become very important as a power source in this country. Just when this will occur is a subject of much debate. Conventional power costs in this country are such that nuclear power may find it hard to compete for quite some time.

In the present world situation where there is strong competition for nuclear superiority, it is reasonable to expect that nuclear power and the other peaceful uses of the atom are going to receive major attention. These efforts along with those of the military, where military effectiveness rather than cost are primary consideration, should result in the widespread application of nuclear power at much earlier date than if nuclear power alone was the only objective.

SUMMARY OF REMARKS BY R. G. ZOOK, ASSISTANT ADMINISTRATOR

R. G. Zook: Let me congratulate those who have prepared for and all of you who have participated in this conference for your efforts in making it the succesaful one which I believe it to be. I think the basis on which this conference has been held provides a fine opportunity for exchange of technical information.

It is my belief that conferences such as this should be continued and I would like to draw your attention to the fact that many of the problems faced by system management in the operation of these rural power systems would probably benefit by the application of the type of analysis and discussions conducted at this conference.

I believe it will be helpful to indicate some of the objectives which I feel our REA electric program should have for calendar 1956. The first concerns itself with our work with borrowers and will provide for continuing emphasis to borrowers on:

a. Better planning -- to include (1) the proper measuring and scheduling of capital investment required for load growth; (2) the establishment of financial objectives, a plan to accomplish them and the putting into effect of that plan.

b. Better management -- to include (1) availability of additional tools to train new and old directors; (2) renewed emphasis on the training of top supervisory operating personnel in practical operating practices; (3) the better use of consultants (engineers, accountants, and attorneys).

With respect to REA's own internal procedure we hope to make available the following:

a. Simplified and better procedures for advancing and accounting for loan funds.

b. Better coordination of procedures in connection with power-type borrowers, including loans, operating reports, and operations projections.

c. The revised REA accounting course for REA personnel and borrowers.

d. Results of further analysis of loan feasibility procedures, looking toward both betterment and shortening of such procedures.

DISCUSSION OF CONFERENCE PAPERS

(Part Two)

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Presented at the 1956 Technical Conference for REA Field Engineers, Saint Louis, Missouri
January 16-20, 1956

REA

U. S. DEPARTMENT OF AGRICULTURE

RURAL ELECTRIFICATION ADMINISTRATION

ABOUT THE CONFERENCE .... The purpose of the Annual Conference for REA Field Engineers is to provide a forum for the discussion of engineering matters concerned with rural electric systems. The objective is to make available to field engineers an opportunity to share views and experience with other engineers who have developed a high degree of experience and specialization in specific fields. Likewise, the objective is to provide the specialist engineer with an opportunity to share his views with those who are facing the practical daily engineering problems.

To assure freedom for the development of ideas which may serve to improve the engineering of rural electric systems, the authors of papers and discussions have been encouraged to explore new ideas and new techniques and to prepare papers which reflect their own engineering judgment and experience. Such an approach may develop ideas which deviate from industry practices and REA policies and procedures presently in effect. It should be recognized, however, that REA policies and procedures as set forth in REA bulletins are still applicable unless changed in the light of the ideas and experience which may result from such papers or discussions.

RGZook

R. G. Zook
Assistant Administrator

DISTRIBUTION VOLTAGE - A COMPARISON OF 12KV AND 4KV SYSTEMS

Discussion and Authors' Closure of
Paper by S. F. Joyce and V. A. Gehrer

H. R. Smith and E. A. Loetterle (REA Engineers, Washington, D. C.): Before proceeding with any discussion of Mr. Joyce's and Mr. Gehrer's paper, I wish to take this opportunity to compliment them on their very fine and comprehensive paper and Mr. Gehrer's presentation. Harry Smith and I were requested to prepare a discussion of this paper and although we prepared this discussion jointly, I have been elected to present the discussion since Harry has another discussion to present later this week.

The paper, as its title indicates, is a comparison of 12 kv and 4 kv systems. Some of our borrowers have had occasion to consider the conversion of 4 kv systems in small towns and villages to 7.2/12.5 kv systems, which I shall henceforth refer to as 12 kv. Consequently they have had to study the advantages and disadvantages of the two voltages. In these cases where the existing 4 kv system was obsolete or badly overloaded the balance weighed heavily in favor of the 12 kv system because the rest of the system was 12 kv and the use of another voltage would necessitate the stocking of a different class of line hardware and equipment. Unless the other considerations weighed heavily in favor of 4 kv the choice has usually been in favor of 12 kv because of the advantage of a single distribution voltage and the greater load carrying capability of 12 kv. Its insurance against the possibility of being unable to serve unpredicted future loads and the fact that the choice only affected a very small part of the system and the total investment also were practical considerations in favor of the higher voltage.

This comparison of a 4 kv system with a 12 kv system that our borrowers have had to make is, however, not equivalent to the authors comparison largely because of the difference in scope. On the one hand we have a very small part of the system, relatively low in cost, involving no transmission and perhaps one substation; whereas on the other hand we have a substantial part of the system, considerable in cost, involving subtransmission and a number of substations. It is believed that greater similarity can be found in comparison of 12 kv and 14.4/24.9 kv systems, which I shall call 25 kv. This is a comparison which a number of our borrowers have had to make and which perhaps a greater number will wish to make in the future. Some of these comparisons will be required preparatory to the construction of new lines; however, in all probability more will be required to determine whether 12 kv should be converted to 25 kv. We would like to point out some of the similarities of comparing 12 kv to 25 kv with the authors' comparison of 12 kv and 4 kv systems. In doing so we shall take advantage of our opportunity and draw on AIEE Transaction Paper, No. 56-3, by W. M. Edmunds and L. B. Crann for some of our facts and figures.

The general considerations that a borrower would employ in the comparison of the two system voltages are largely identical with those listed by the authors. However, it may be necessary for some of our borrowers to consider transmission as well as sub-transmission. (In this connection we would like to ask the authors what lines they designate subtransmission.) It is also quite probable the secondary system would be omitted from the list of items to be considered by the average borrower. There is only an average of 1.25 consumers per transformer on REA systems. Consequently most consumers have their own transformer and present practice is to locate the transformer as near as possible to the load center. In

low density areas where 25 kv is most apt to be considered practically every consumer will have its own transformer.

Most REA Borrowers do not own generation and transmission facilities. The average borrower has practically all of its investment in its distribution system. Therefore economical methods for increasing the capacity of these distribution systems to handle their growing loads are very attractive. Increasing the number of supply points, adding new circuits or additional phases to existing circuits and increasing the distribution voltage, are the general methods employed.

Practically all REA Borrowers adopted 12 kv as their primary voltage at the very beginning. They all serve what would be considered low density areas. This standardization and the standardization of materials and structure designs plus the large amount of materials and equipment used have resulted in low cost construction. This choice of voltage was a good one, and still appears good for these low density systems.

After World War II a number of borrowers extended lines into what may be called very low density areas. (By very low density we mean in the order of one consumer per mile. We note that the authors use the term light density areas and we would appreciate their telling us what they consider light density areas.) Transmission lines and power sources were generally far apart in such areas. 25 kv systems proved to be a feasible way of bringing power to these very thin areas. When the 25 kv lines were first proposed the lowest priced distribution transformers cost over $500. each. However, manufacturers soon made transformers available for this voltage and in the desired sizes at less than half this price. This helped 75 borrowers justify and build approximately 33,000 miles of 25 kv distribution lines.

The main advantages of high voltage distribution are as pointed out by the authors. In the typical case, increasing the voltage from 12 kv to 25 kv increases the load carrying capability approximately four times. For a low density rural system the total cost of a new 25 kv line is about 20 percent higher than for a new 12 kv line with the same size conductor and phasing.

Thus the cost per kw of capacity of this higher voltage line is approximately 1/3rd of the cost of the 12 kv line with the same conductor size and phasing.

As far as tree trimming is concerned, there is no serious difference between 12 kv and 25 kv. Hot line tools are required to work either of these distribution lines while energized. In general our borrowers also find it harder to prove it economical to convert a working 12 kv system to 25 kv. The added costs of the higher priced transformers is one of the deterrents. The use of 25 kv lines as express feeders or as subtransmission has been proved economically attractive for heavying up existing system or parts of a system by a number of system engineers. The average weighted age of REA Borrowers' systems is now approximately 10 years, therefore methods to increase capacity by keeping existing facilities and materials in service are usually attractive. A plan that obsoletes large amounts of materials and equipment that still have 2/3 of their useful life remaining in most cases will not be the best plan.

Each REA Borrower has special design problems. It is therefore recommended that each borrower have adequate system planning studies made and kept up to date, to provide guidance for the economical development of its facilities to handle its

growing loads. General conclusions or studies that have been made for other systems cannot take the place of specific engineering studies to meet the borrowers' own specific conditions and needs.

S. F. Joyce: Ours is not truly a rural system as we serve large towns and cities in our area and much of the so-called rural territory in Union Electric's service area is suburban in nature. Some of it is pretty thin in the Ozark hills, but our average, excluding towns, is probably 3 to 4 customers per mile.

We are considering our entire area in discussing the voltage problem, including St. Louis, East St. Louis, Alton and Keokuk, which are heavily industrialized as well as having a densely built-up residential area in and immediately around them. These have been thoroughly covered at 4 kv, in some cases for many years, and feeders are short and heavy. In St. Louis, feeder loads of 3000 to 3500 kva at 4 kv are common.

In the adjacent counties, lines were light and were originally 2400 volt single phase or 4 kv single-phase (two phases from 4 kv wye system with no neutral). These areas are being cut to 12 kv wye, including sizeable towns. All new substation capacity will be installed at 12 kv, and 4 kv will eventually disappear. Substations as well as lines in the 4 kv portions were light and scattered and we have reached the stage where two counties now have only one 4 kv substation in each, located in towns, and another has three, each located in a town. In these cases, each 4 kv substation area is an "island", surrounded by 12 kv substations and circuits.

In St. Louis, East St. Louis and Alton, we believe that 4 kv distribution will be continued due to the high stage of its present development. The portion of St. Louis County immediately adjacent to St. Louis will also probably remain at 4 kv, but the outer portions of it, about five miles beyond city limits, is being cut to 12 kv.

FAULT PROTECTION FOR THE UNION ELECTRIC
SUBTRANSMISSION AND RURAL DISTRIBUTION CIRCUITS

Discussion and Authors' Closure of
Paper by Ren Beatty and I. F. Krughoff

L. B. Crann (REA Engineer, Washington, D. C.): The authors have done an excellent job in giving us a clear picture of the fault protection practice and maintenance practices of the Union Electric Company. I am sure that all of us will agree that the information presented will be very helpful to us in our work.

The information submitted on recloser maintenance is of special interest to us in view of the high priority which we have placed on this phase of system operations. Continuity of service and safety to operating personnel in particular demand that we maintain our reclosers and maintain them adequately. In this respect, adequate maintenance is not the mere replacement of oil at periodic intervals but is the process of restoring the recloser electrically and mechanically to a sound operating condition. This requires equipment, knowledge and a systematic standard for maintenance. We would like to discuss these points further and possibly obtain additional details from the authors on Union Electric Company's practices.

The Standard for maintenance on page 4 is a good one and one which any utility could profitably follow. We in REA have not attempted to write as rigid a standard but then our problems are different. In effect all we say is to follow the manufacturers' recommendations for the particular recloser to be maintained. These recommendations, in several cases, differ from those on page 4 with respect to the frequency of inspections. For example, although the Line Material Company recommends yearly inspection and maintenance, it also ties in the frequency of maintenance to the recloser size with recommendations for inspection, ranging from a maximum of 50 operations for 50 amp type H reclosers to 250 operations for 5 ampere reclosers. The General Electric Company maintains that inspection of its recloser can be put on a three year basis or after a number of operations varying from a minimum of 75 to a maximum of 900 depending on the maximum fault current available at the recloser installation. Apparently the General Electric Company considers moisture to be the principal cause of oil contamination rather than the breakdown products of oil due to arcing. We would be very interested in the authors' viewpoint and experience on this subject. We would also like to know whether the experience of the Union Electric Company to date is such that longer periods between maintenance can be considered to be safe?

The need for adequate equipment to maintain oil circuit reclosers does not appear to be fully appreciated by all REA borrowers. The reference in the maintenance standard to the availability of proper facilities for oil testing and changing implies equipment which many borrowers do not have but is essential for proper maintenance. We consider an oil dielectric tester and an insulation tester similar to the L-M dc tester to be the minimum test facilities for a borrower doing its own maintenance. Certainly an oil dielectric tester because experience has shown time and again that new oil is not necessarily free from moisture. If the oil is dry when received, it soon absorbs moisture after the drum has been opened. Therefore it is essential that all oil be tested for dielectric strength before being used.

Some means for testing the condition of the recloser insulation, such as the stringers, bushings etc., must be provided for if the recloser is to give satisfactory service after being maintained. A high voltage dc tester permits the testing of solid insulation and is an essential piece of test equipment for all borrowers.

In addition to these two basic items of test equipment, other facilities are very desirable. An oil filter press removes moisture from oil and raises the dielectric strength of the oil to a safe value. In many cases the savings in oil may justify the purchase of this equipment and its associated filter paper oven.

A ventilated drying oven is also very useful in maintaining oil circuit reclosers. With time, certain insulating parts absorb moisture and these parts must either be replaced or dried. In many cases, drying will prove to be the most economical method of handling this problem.

Quite obviously, room must be set aside in a building to house these test facilities and to store the reclosers after they have been maintained.

With respect to testing the reclosers for timing after they have been maintained, we have hesitated to recommend the equipment necessary for this work because of the cost. In most cases, automobile batteries are adequate for an approximate determination of the pickup current of the recloser and the mechanical operation can be determined manually. This is a far cry from the timing check which the Union Electric Company apparently makes. The experience recorded in Data Sheet "A" shows a high percentage of defects affecting the timing mechanism of new reclosers. This leads us to wonder whether some of our field troubles with coordination can be traced to defects in the timer and whether we should not reconsider the needs for test equipment to check the timing. The authors state on page 4 their belief that their policy of testing new reclosers has led to a number of improvements on the reclosers as manufactured. Has this improvement showed up in fewer timing complaints on new reclosers?

We note that under the "Used" heading of data sheet "A" that no timing complaints are listed. Can we infer from this that once the timer is correctly set further trouble should not be expected?

We wonder if the authors can give us further information on the equipment used for testing the reclosers for operation. What voltage does it operate at, what is the current capability, and how does it handle mechanical timer reclosers such as the General Electric Companys' without having to dismantle the contact assembly? Any information which is available will be appreciated.

Ren Beatty and I. F. Krughoff: The authors wish to thank Mr. L. B. Crann for his discussion of their paper presented at the 1956 REA technical conference in St. Louis, Missouri.

Under paragraph three we feel that, with the exception of some sectionalizers, the most indicated need for maintenance on reclosers returned to our shop has been directly proportional to fault duty. Reclosers coming in with from 60 to 100 operations show considerable accumulation of carbon and contact burning. Occasionally reclosers with less than 50 operations show the same signs, presumably from

fault duties at or near their ratings. We have found some few cases where sediment has prevented closure of the ball type valves. This has caused timing errors and has resulted in a variation in the number of reclosures to lock out. Moisture has not been a problem in the hydraulic type except in some sectionalizers. We do not believe that the period between maintenance should be increased.

We agree that oil should be checked for dielectric breakdown before being used. In the shop we have relied on making a high potential test (25 kv for 14 kv reclosers) to determine condition of the insulation. We have not made any field tests with D. C. Some power factor tests have been made with the Doble Equipment but we do not make a practice of this.

Under paragraph 6 we have not yet found a need for the drying oven in the shop. We do have facilities at other system locations for such drying if found necessary.

With regard to checking the operating times of reclosers, some of the cases under the item "Timing Off" were found with the mechanical type timer. They, of course, were easily reset. Some of the hydraulic type reclosers are not capable of being adjusted for time errors. For that reason we held this type to rather close tolerance so that any wear in service would not place them outside of our timing schedule too soon.

We believe that we have had fewer timing troubles with new reclosers by holding our tolerances fairly close.

In paragraph 9 we assume that Mr. Crann is talking about mechanical timers. If they are found off they can be easily reset. As mentioned above some hydraulic types are not readily adjustable. They should not change except by wearing of the parts or by fouled valves.

Our recloser test equipment is supplied from a fairly heavy 480 volt source through a 25 kva buffer transformer to a 120/208 grounded wye system. A single phase loading transformer is used to supply simulated fault currents at voltages from 24 to 96 volts.

This transformer has 2 115v. winding (each 2 #9's in parallel) which may be connected in series or parallel. For some tests 208 volts is applied to the 115v. coils in parallel.

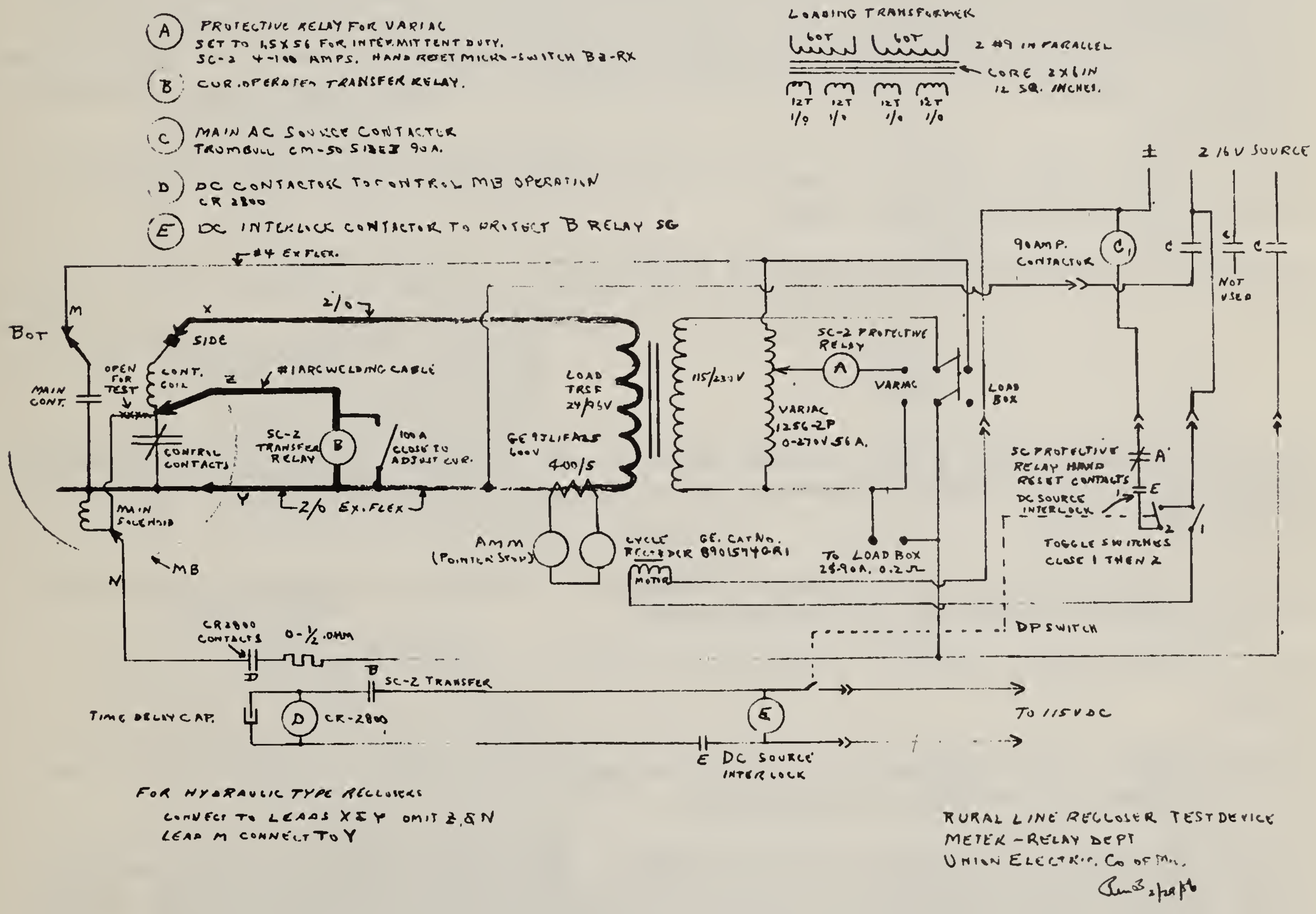
The low voltage consists of 4 separate windings (each 1/0 copper) rated at 24 volts. These can be connected in parallel, series-parallel or series to give several test voltages.

Our test setup is capable of supplying 2000 amperes to a 280a. recloser. This is 3.6 x pickup and will cause the recloser to operate about midway down the time curve. While we are not able to test at full interrupting capacity we feel we are providing adequate checks for correct operation. Our field experience backs this up. Small reclosers can be checked at currents nearer their high current capacity.

We use a shop built control center to control the testing of the reclosers. A remote control contactor energizes the loading transformer primary to start a test cycle. Lock out of the recloser stops the test. Open and close times are indicated by a weld timer which counts the cycles of simulated fault current applied to the reclosers.

For mechanical clock type reclosers such as the R & IE MB series a contactor shunted by capacitors is used to maintain power on the operating coil for a sufficient time to simulate the arcing time at normal operating voltages. This eliminates the need for dismantling the contact assembly.

A diagram of our test set up is attached.



Discussion and Authors' Closure of Paper
By George W. Couch and M. G. Cox

John G. Hieber (REA Engineer, Washington, D. C.): The Authors have made an excellent presentation and are in substantial agreement with many others concerning the essential nature of maintenance. There are several points I would like to mention.

The maintenance problems of REA borrowers differ from that of many others mainly in density of loads per unit of area. While their service standards are high, the revenue available for maintenance is often less.

Why preventive maintenance? Because it permits planned work under ideal conditions at a convenient time. It should reduce hazards to both employees and the general public. By reducing outages, more revenue is available from energy sales and public relations are improved. After a new line has been completed and before the line is energized for service, a complete climbing inspection should be made by the borrower's operating department to make sure that everything is in good operating condition.

Is one pilot able to fly the plane and inspect the line? Some reports indicate that a pilot and observer are used.

Reported costs per mile of patrolling a line are:

1. Air patrol	\$ .46 to \$ .60
2. Jeep	\$1.28
3. Foot	\$1.93 to \$2.75

Reports indicate that the air patrol can see some items at the top of the structure which cannot be seen from the ground while ground patrolmen can inspect the base of structures better.

Some other methods of right-of-way clearing are bulldozers, power driven saws and water weighted rollers with attached knives.

One utility reports the use of spirolum whirlers to scare woodpeckers away from poles.

Table 1 which lists some causes of line outages may be helpful in making improvements in system operation and maintenance.

Lightning caused 69.5 percent of the outages. This indicated that proper maintenance of the overhead ground wire can be helpful. Unknown outages of 6.24 percent shows need of trained observers, measuring instruments, and proper records. Line or equipment failure of 6.06 percent is related very closely to maintenance and causes most of the permanent outages. Any reduction in maintenance would make this type of outage much higher.

Natural phenomena other than lightning accounts for 6.76 percent of the outages. Preservation of line design strength is important in keeping such outages low.

Table 2 indicates that approximately 60 percent of the faults are line to ground. Good line to ground relaying is desirable to prevent more severe types of faults.

Table 3 indicates that approximately 90 percent of the faults are of the temporary type. Prompt reclosing of breakers either automatically or by operators will keep outage time at a minimum.

Table 4 shows estimated annual operation, maintenance and replacement costs for lines. This information is often used in new power cost studies where more accurate data is lacking.

TABLE 1

LINE OUTAGES 100-125 KV CLASS
(AIEE TECHNICAL PAPER 52-6)

	NUMBER	PERCENT OF TOTAL
A. NATURAL PHENOMENA		
1. Lightning	11,511	69.50
2. Earthquake, fire, flood	53	.32
3. Wind, tornado	363	2.19
4. Sleet, ice	332	2.00
5. Dirt, fog, gases	122	.74
6. Galloping conductor	251	1.51
B. SYSTEM DESIGN		
1. Switching surges	123	.74
2. Dynamic overvoltages	11	.06
3. Undesired relaying	634	3.82
4. Instability (static)	10	.06
5. Instability (transient)	168	1.01
6. Instability (loss of generator)	7	.04
C. HUMAN CAUSES		
1. Gunfire, sabotage	31	.18
2. Personnel error	291	1.75
D. LINE OR EQUIPMENT FAILURE		
1. Protector tube failure	32	.19
2. Terminal equipment failure	538	3.24
3. Underground cable failure	14	.08
4. Mech. failure structure	53	.32
5. Mech. failure conductor	144	.87
6. Mech. failure insulator	183	1.10
7. Mech. failure static wire	44	.26
E. FOREIGN OBJECTS		
1. Airplanes	56	.34
2. Land vehicles	77	.46
3. Kites	5	.03
4. Birds	70	.42
5. Animals	3	.02

TABLE 1 - CONTINUED

	NUMBER	PERCENT OF TOTAL
6. Trees	123	.74
7. Miscellaneous	47	.28
8. Unclassified	96	.58
D. OTHER		
1. Miscellaneous	151	.91
2. Unknown	1,036	6.24
Total	16,579	100

TABLE 2

(AIEE TECHNICAL PAPER 52-6)

TYPE FAULT

	NUMBER	PERCENT
1. L-G (Line-ground)	9,750	58.9
2. L-L	1,315	7.9
3. LL-G	1,797	10.8
4. LLL	536	3.2
5. LLL-G	871	5.2
6. Unknown	1,637	9.9
7. None	531	3.2
8. Overload tripping	142	.9
Total	16,579	100.0

TABLE 3

(AIEE TECHNICAL PAPER 52-6)

TYPE OUTAGE

	NUMBER	PER 100 MILES PER YEAR	PERCENT
1. Temporary	15,030	12.33	90.6
2. Permanent	1,307	1.07	7.9
3. Not reported	242	.20	1.5
Total	16,579	13.60	100.0

TABLE 4

ESTIMATED ANNUAL EXPENSE
PER MILE FOR WOOD TRANSMISSION
LINES. REA DATA.

LINE KV	OPERATION & MAINTENANCE	REPLACEMENT
34.5	$ 65.	$32.
46.	69.	34.
69.	80.	48.
115.	90.	60.
138.	110.	76.
161.	140.	97.

G. W. Couch and M. G. Cox: Mr. Hieber's discussion of our paper is interesting and well prepared. We are happy to say we are in agreement on the points discussed.

Concerning a pilot's ability to fly and inspect transmission lines, our experience indicates that small, fixed-wing planes with low landing and flying speeds are safer, more economical and suitable for transmission line patrol than the higher speed heavier planes. Due to the load limitations of lighter planes and maneuverability requirements, our pilot considers flying and inspecting alone to be safer.

We have compared the results of flying with or without an observer and have concluded that an experience pilot, trained in line patrol, can do a safe and satisfactory job of flying and inspecting high voltage transmission lines in our operating area.

We have tried to show how some of our transmission maintenance and operating problems are met at Union Electric Company of Missouri, however, we appreciate that maintenance and operating practices vary with conditions, requirements and location. We hope that by relating our experiences, we have stimulated thinking that will help in dealing with some of your maintenance and operating problems.

We wish to express our thanks and appreciation for your discussion and interest accorded our paper.

LOAD DISPATCHING IN UNION ELECTRIC SYSTEM

Discussion and Authors' Closure of Paper
by J. K. Bryan, J. F. McLaughlin and L. A. Mollman

W. E. Rushlow (REA Engineer, Washington, D. C.): The Union Electric System has a generating capacity of about 1,600,000 kw in nine plants, which if run at a 100% load factor could produce 98% of all the kwh's purchased by all of the REA borrowers during the fiscal year ending June 1954. REA's largest generating borrower, the Dairyland Power Cooperative, has an installed nameplate capacity of about 136,000 kw, also in nine plants. These plants consist of run-of-the river hydro, storage hydro, oil burning internal combustion, gas burning internal combustion and coal fired steam plants. The machine sizes range from 200 kw hydro units to 30,000 kw steam units with a 50,000 kw steam unit presently being installed. This borrower has over 2100 miles of transmission line in voltages up to 161 kv. At the other extreme our smallest, completely self-contained generating borrower has 2-100 kw oil burning internal combustion engines. At the present time, there are only about seven percent of the REA borrowers having steam plants which are not interconnected with another source of supply and these are expected to be interconnected in the near future. Tie line loading, economic loading of units and plants, automatic load control and the various types of communications apply in whole or in part to REA borrowers. Even though the load dispatching, as described in this paper, is much larger in scope and more complete in detail, the basic problems are the same. However, the bigness on one hand and the smallness on the other emphasizes certain problems for one which might be of minor importance to the other. The problem of allocating the load economically is forever present when you have more capacity than what is required to meet the load, and therefore the economic dispatch of generation is of particular interest.

Some of our borrowers have their thermal generating capacity concentrated in a small area, whereas for others it is spread throughout a large area and transmission losses become an important consideration in determining the economic cost of delivered power. To what extent the cost of transmission losses are considered by the Union Electric Dispatchers and the Betterment Group would be of interest.

The use of hydro plants in conjunction with thermal generating plants produces some interesting combinations depending primarily on the amount of water and storage available. Figures 4 and 5 show the use of hydro as base load and peaking capacity. In these examples, the kwh's contributed by the hydro plants in each of these cases were in the ratio of about four or five to one, whereas the kw was in the ratio of about two to one. Other than when there is too much water available who determines whether the Osage hydro should produce kwh's or kw's; are incremental costs assigned to hydro and how are they figured?

Curve No. 5 shows a peak of 1,200,000 kw. The capacity figures of the various plants appear to be capability rather than nameplate, and although it is difficult to tell exactly, it seems that all the thermal plants are loaded to "three bells and a jingle," and the spinning reserve is in the form of stored water. This, of course, is another advantage of hydro. Ability to store water to be used at any particular time becomes even more important to an interconnected system as the dispatcher might find it more economical to buy off peak or dump thermal power instead of using his hydro, thus storing water to be used on the peak or to be sold to other members of the interconnection.

The problem of spinning reserves becomes serious and expensive to REA borrower not having interconnections, where a big percentage of their total generation is concentrated in a small number of units. The rule of thumb or basic considerations given by Union Electric Dispatchers to spinning reserve would be of interest.

The night-time loading of the Cahokia plant shown in Fig. 4 does not appear obvious, particularly when it is necessary to reduce load on Meramec in order to carry some load on Venice. On rural systems, the night-time minimum demand is a much smaller percentage of the peak demand than that shown in Figs. 4 and 5 and how to meet the night-time load considering spinning reserve, economic loading of units, cost of starting and stopping steam units and associated maintenance becomes a major problem. The factors influencing the keeping of Cahokia operating at minimum load would also be of interest.

One of the most difficult things for the operators in the smaller plants to understand is that the overall cost may be less if more load is carried on a unit having a greater monthly average cost and less load carried for a unit having a smaller monthly average cost. This comes about because incremental loading takes into consideration what it costs for the little piece being added and frequently it costs less to add a kwh on a high cost unit than it does on a low cost unit. Incremental rates are affected by whether the overall average of the unit is increasing or decreasing with the next increment and what has happened beforehand. Time does not allow a lengthy discussion, but a somewhat similar comparison could be made in bowling. Assume two bowlers: one with a 150 average for three games and the other with a 140 average for 20 games. If each bowler wishes to increase his average one pin in the next game, the 150 bowler must roll 154, whereas the 140 bowler must roll 161. You might say the 150 bowler has in incremental rate of 154, and the 140 bowler an incremental rate of 161.

Figure 3 on incremental loading of units shows the most economical method of loading is to partially load a machine to a point and to change from one machine to another, depending on the particular incremental heat rate curve for each machine. The curves in Fig. 3 could also apply to plant output. This would indicate that individual plants are loaded by taking increments from one plant, then another, and switching back and forth depending on the plant incremental heat rate curves. Figs. 4 and 5 give the impression that the lowest cost plant is loaded to its maximum capability first, then the next lowest to its maximum capability, etc.

The statement by the authors that: "It is expected that system peaks will continue to occur in the summer due to steadily increasing acceptance of summer air conditioning. Only a major change in the use of electric power can change this trend," should be of more than passing interest to most of the conferees. I believe at the present time, for other than irrigation loads, this is not typical of rural areas. Although some of the cooperatives in the neighborhood of St. Louis do have their maximum peak at noon during the summer, the highest peak still occurs at night during the winter months. This may be a prophesy of things to come on rural areas and any details or use statistics may be of considerable interest to the Power Use people.

The authors are to be congratulated in the treatment of a complex and specialized subject in such a broad and fundamental manner. Such a presentation must necessarily deal with the highlights of the subject only, and this discussion was intended to bring out the areas of similar or opposite problems with a view towards provoking further discussion.

L. A. Mollman: Union Electric does not now include transmission line losses in determining the economic loading of plants. All steam plants are located adjacent to the Metropolitan St. Louis area - the load center. The two hydro plants are at some distance from St. Louis, but due to area loads in their vicinity and due to hydro availability line losses are not involved in their operation.

The Keokuk Plant is a run-of-river plant and, therefore, its use is based on the flow. The Osage Plant is a storage plant. Capacity and energy rule curves have been produced for this plant. The capacity rule curve (higher pond elevation) is followed when the system is in a tight capacity situation such as just before a new steam unit and the energy rule curve (lower pond level) is followed when there is plenty of steam capacity. System conditions are examined and which rule curve to follow is the result of their studies.

The Illinois-Missouri Pool maintains spinning reserve sufficient to reserve the largest unit operating in the pool. Each of the three companies is responsible for a share of this equal to their share of the pool load.

The nighttime load of Cahokia Plant is based on the anticipated next day's load. Because of boiler plant operating limitations best overall operation results if the nighttime load is equal to about one-fourth of the anticipated requirements at 9:00 AM.

The comments relative to incremental loading of plants is correct. The incremental cost sheet shows bands of plant capacity as they occur in cost sequence. The result is, as stated, one band of capacity at a plant may fit between two bands at another plant. Figures 4 and 5, for reasons of simplification, do not show each band.

DISCUSSION OF CONFERENCE PAPERS

(Part Three)

Contents | Page

Presented at the 1956 Technical Conference for
REA Field Engineers, Saint Louis Missouri
January 16-20, 1956

U. S. DEPARTMENT OF AGRICULTURE

RURAL ELECTRIFICATION ADMINISTRATION

ABOUT THE CONFERENCE .... The purpose of the Annual Conference for REA Field Engineers is to provide a forum for the discussion of engineering matters concerned with rural electric systems. The objective is to make available to field engineers an opportunity to share views and experience with other engineers who have developed a high degree of experience and specialization in specific fields. Likewise, the objective is to provide the specialist engineer with an opportunity to share his views with those who are facing the practical daily engineering problems.

To assure freedom for the development of ideas which may serve to improve the engineering of rural electric systems, the authors of papers and discussions have been encouraged to explore new ideas and new techniques and to prepare papers which reflect their own engineering judgment and experience. Such an approach may develop ideas which deviate from industry practices and REA policies and procedures presently in effect. It should be recognized, however, that REA policies and procedures as set forth in REA bulletins are still applicable unless changed in the light of the ideas and experience which may result from such papers or discussions.

R G Zook

R. G. Zook
Assistant Administrator

SYSTEM IMPROVEMENT PLANNING

Discussion and Author's Closure of Paper by W. J. Hauck

J. B. Davis, G. F. Moon and E. D. Tatum (REA Engineers): The foregoing paper by Mr. W. J. Hauck on System Improvement Planning advocates that system studies should include a rough estimate of the saturated system and that the estimate should be based on an average usage figure of at least 3,000 kwh per farm and non-farm members exclusive of large power consumers. The purpose of this discussion is to emphasize the following:

1. Whether or not 3,000 kwh or some lesser estimate is selected for the saturated system, advance planning is workable from a practical standpoint. Expensive alterations to an existing system will not necessarily be involved. It will not necessitate a maze of recommendations and counter recommendations by the system study engineer.

2. If sub-transmission voltage and conductors of greater capacities than No. 2 copper are not desired, it is not necessary to plan toward their use.

3. The planning for the saturated system need not be a rough study. It could be made an integral part of the system study.

4. The advance planning will not necessarily be dangerous in the hands of an unwise manager.

5. System studies based on saturation levels should also include preliminary studies of the borrower's retail rate structure at several of the usage levels.

In view of the fact that we presently think in terms of 500, 600, 700 or 800 kwh averages for the ultimate in system studies, it is possible that to advocate at this time a 3,000 kwh system study the plan might at first glance be viewed with alarm. At least the plan might meet considerable opposition or open skepticism as to its workability.

To envision usages of 3,000 kwh per member per month requires considerable foresight. However, a considerable amount of foresight would have been required in the early days of REA to see the present attainment of usages of 500 and 600 kwh for a considerable number of our systems. Prior to the formation of the Rural Electrification Administration the entire electric industry did not have the foresight to envision rural electrification as a profitable business venture.

It is agreed that a system with an advance plan for saturated usage may never reach its goal. However, if a system cannot achieve the averages set by the advance plan, the recommendations of the plan beyond the applicable usage level will simply lie dormant. It might be said that in such cases a part of the costs of the advance plan have been wasted. But planning costs are small. Meanwhile, if the advance plan has precluded the installation of one mile of line which may not later fit into the pattern of the system, the cost of the entire system study will in effect be recovered.

In the interest of producing concrete evidence to form the basis for the statements included in Items 1 and 2 above, Exhibits A, B, C and D show a portion of an imaginary system with recommendations to carry it through a 3,000 kwh level. It is expected that these exhibits will tend to bring the matter of studies for saturated systems through its nebulous stage into actuality. It will be noted that the assumed portion of the system is probably typical in that it is 7.2/12.5 kv, its farthest point on the line is 29 miles from the source and most of the line is of No. 6 copper conductivity. However, it is probably not typical with respect to the number of members along the lines. The density has been increased to approximately five per mile so we will not have assumed an easy situation. In keeping with the knowledge that the conversion of existing systems to sub-transmission voltages is a costly operation, no advantage has been taken of the capabilities of 14.4/24.9 kv lines. The system remains at 7.2/12.5 kv through its saturated stage of planning. Exhibit A indicates that only two recommendations are necessary to bring the system from 300 kwh to an approximate 1,000 kwh level of consumption. These are the installation of voltage regulators at Point C and the conversion of four miles of line from I to K. Exhibit B indicates that for the saturated system at an average usage level of 3,000 kwh per month, a new source must be obtained at or near Point E and that 9 miles of conductors from Point E to I must be changed from No. 6 copper to No. 2 copper conductivity. Exhibits C and D are the voltage drop calculations to accompany Exhibits A and B.

The advance planning recommendations are simple and would be in strict keeping with the balance of the recommendations made in the system study. The costs for the advance planning are negligible. The costs of the recommended improvements are not prohibitive. In some cases the new source may simply be a matter for negotiation with the power supplier.

Assume that Exhibit A represents a portion of a system on which a study has been made based on an ultimate (10-year) level of average usage of 700 kwh per member per month. Further assume that we have discounted the value of advance planning beyond the 10-year period and are holding to present policy of economical design for the estimated 10-year level. The voltage regulators at Point C would not be specified. Instead the cooperative would justifiably convert the line from A to B to 1/0 conductivity and the line from B to C to No. 2 conductivity in order to hold to an approximate seven percent voltage drop for the ultimate system at Point K. Exhibit C illustrates that the solution is in direct opposition to the true needs for this portion of the system over its approximate 30-year life.

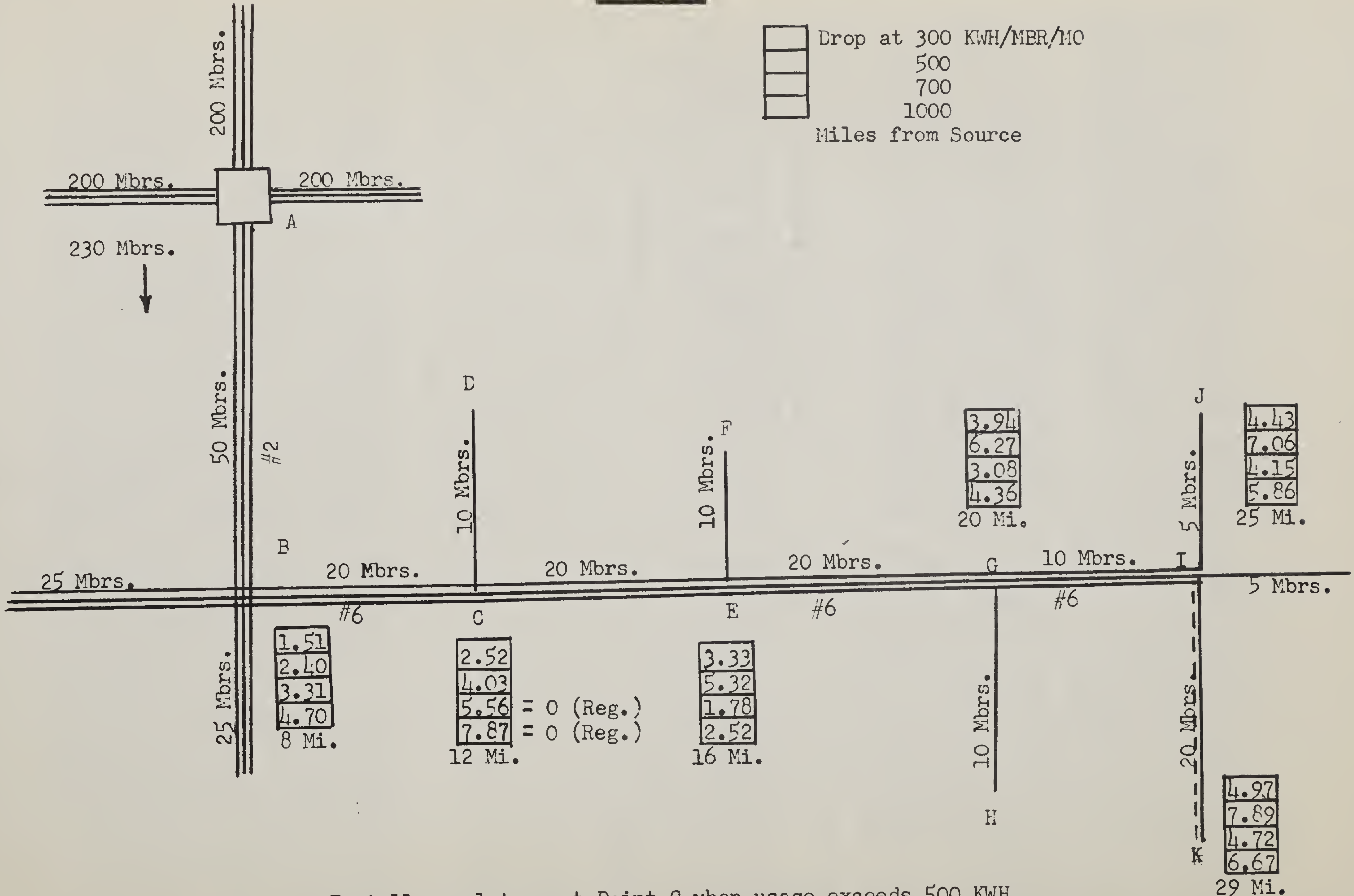
In connection with the preparation of estimates for the 2, 5 and 10-year kwh levels that an individual system is expected to achieve,REA presently takes into consideration the past history of the system with respect to its usage trends, the various types of loads, competition by natural and manufactured gases, the general economic conditions of the area and the dilution of the over-all kwh average caused by the number of new members expected to be added to the system. The completed estimates are forwarded to the cooperative for the consideration of its board of directors. The board is invited to submit its own estimates for REA's further consideration in the event the recommended estimates do not appear reasonable to the board. Under such procedure the responsibility for the final selection of the ultimate level rests with the board of directors of the individual cooperative. The procedure is good. It is believed that it should continue and it is believed that more realistic estimates at saturation levels can be obtained for each system in the same manner rather than the use of an arbitrary kwh figure for all systems. Whether or not this will constitute a compromise at some saturation level below 3,000 kwh does not appear to be as important as the individual consideration given to each system.

Owing to the wide range of needs and because of the individual personalities of the managers and the boards of directors for REA borrowers, it is difficult to formulate policy or procedure which will fit the needs of all borrowers. However, it is believed that a majority of REA borrowers will not object to retaining the same system study engineer over a period of years. Therefore, it appears that engineering service contracts for system studies which include plans for a saturated system could provide for an annual review of the study during which time the construction program for the next 12 months could be planned.

Because of the sliding scale on which the retail rate structures for most REA systems are based, it is reasonable to assume that for a saturated system most of the usage will be at the lowest energy rate specified by the cooperative. This may not represent an adequate return on the owner's investment. It is not a situation which would be undetected over a period of years. However, it is a situation for which preparations should be made. Therefore, it is believed that system studies which include plans for a saturated system should also include sufficient preliminary rate studies to show at various kwh levels whether or not a revision in the retail rate structure is necessary.

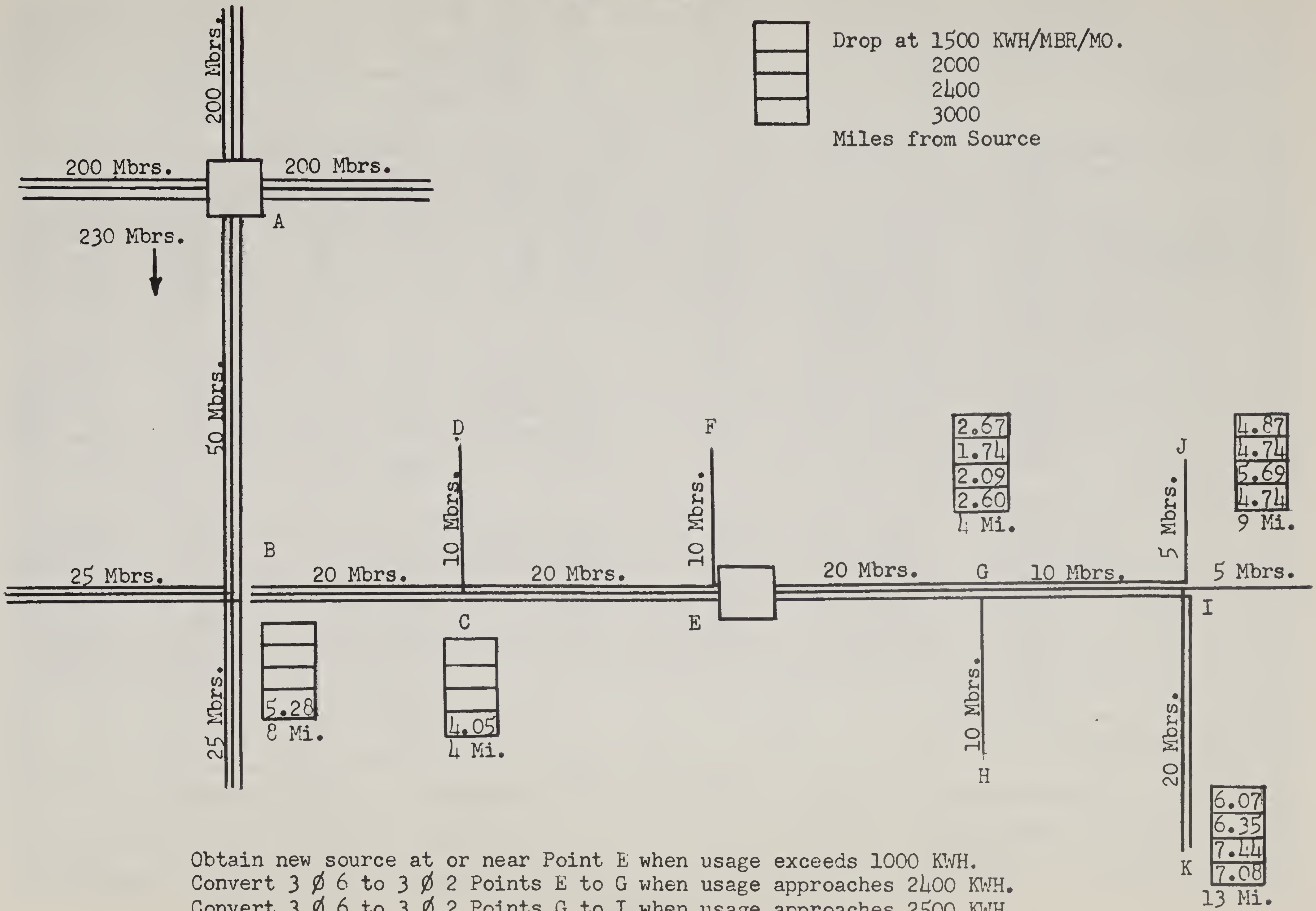
System improvement planning on the basis of a saturated system is practical. However, it is believed that more realistic estimates for the saturated system can be obtained through REA's present method of estimating rather than the selection of a minimum kwh level for all systems. All new system studies should include a plan for the saturated system. The engineering service contracts for system studies should include the provision that the engineer review the study each year with the owner and aid in the construction plan for the next 12 months. The system study should contain preliminary rate studies at various levels of usage in sufficient detail to determine whether the cooperative will receive an adequate return on its investment.

EXHIBIT A



Install regulators at Point C when usage exceeds 500 KWH.
Convert 1 Ø 6 to V Ø 6 Point I to K when usage approaches 700 KWH.

EXHIBIT B



Obtain new source at or near Point E when usage exceeds 1000 KWH.
Convert 3 Ø 6 to 3 Ø 2 Points E to G when usage approaches 2400 KWH.
Convert 3 Ø 6 to 3 Ø 2 Points G to I when usage approaches 2500 KWH.

EXHIBIT C

REA FORM 239 (3-53) FORMERLY DS-163R1

U.S. DEPARTMENT OF AGRICULTURE
RURAL ELECTRIFICATION ADMINISTRATION

VOLTAGE DROP SHEET

PROJECT

SUBMITTED BY

~~CHECKED BY~~

Wentworth Substation

SHEET OF SHEETS

DATE SUBMITTED

DATE CHECKED

PHASE(S)

	Section	Number of Consumers: Signed	Potential	Ultimate	Beyond This Section	Equiv. This Section	KWH per Month	KW Peak	Length of Section in Miles	KW Miles	Conductor Size Cu. Equiv.	Ø / KV	Wire Factor	% Voltage Drop: This Section: Concentrated Load	Distributed Load	Sum	Total	At Point
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
300 KWH	A to B	50	0	50	180	205	300	225	8	1800	2	3 Ø	.838		1.51			
	B to C	20	0	20	110	120	300	145	4	580	6	"	1.76		1.01			
	C to E	20	0	20	80	90	300	115	4	460	6	"	1.76		.81			
	E to G	20	0	20	50	60	300	87	4	348	6	"	1.76		.61	3.94		
	G to I	10	0	10	30	35	300	55	5	275	6	"	1.76		.49	4.43		
	I to K	20	0	20	0	10	300	20	4	80	6	1 Ø	6.70		.54	4.97		
500 KWH	A to B	50	0	50	180	205	500	358	8	2864	2	3 Ø	.838		2.40			
	B to C	20	0	20	110	120	500	231	4	924	6	"	1.76		1.63			
	C to E	20	0	20	80	90	500	184	4	736	6	"	1.76		1.29	5.32		
	E to G	20	0	20	50	60	500	135	4	540	6	"	1.76		.95	6.27		
	G to I	10	0	10	30	35	500	89	5	445	6	"	1.76		.79	7.06		
	I to K	20	0	20	0	10	500	31	4	124	6	1 Ø	6.70		.83	7.89		
700 KWH	A to B	50	0	50	180	205	700	495	8	3960	2	3 Ø	.838		3.31	3.31		
	B to C	20	0	20	110	120	700	318	4	1272	6	"	1.76		2.25	5.56	(Regulators)	
	C to E	20	0	20	80	90	700	253	4	1012	6	"	1.76		1.78	1.78		
	E to G	20	0	20	50	60	700	185	4	740	6	"	1.76		1.30	3.08		
	G to I	10	0	10	30	35	700	122	5	610	6	"	1.76		1.07	4.15		
	I to K	20	0	20	0	10	700	43	4	172	6	V Ø	3.35		.57	4.72		
1000 KWH	A to B	50	0	50	180	205	1000	700	8	5600	2	3 Ø	.838		4.70			
	B to C	20	0	20	110	120	1000	450	4	1800	6	"	1.76		3.17	7.87	(Regulators)	
	C to E	20	0	20	80	90	1000	358	4	1432	6	"	1.76		2.52			
	E to G	20	0	20	50	60	1000	262	4	1048	6	"	1.76		1.84	4.36		
	G to I	10	0	10	30	35	1000	171	5	855	6	"	1.76		1.51	5.87		
	I to K	20	0	20	0	10	1000	60	4	240	6	V Ø	3.35		1.80	6.67		

EXHIBIT D

REA FORM 239 (3-53) FORMERLY DS-163a1

U.S. DEPARTMENT OF AGRICULTURE
RURAL ELECTRIFICATION ADMINISTRATION

VOLTAGE DROP SHEET

PROJECT

SUBMITTED BY

~~CHECKED BY~~ Robinson Substation

SHEET OF SHEETS

DATE SUBMITTED

DATE CHECKED

PHASE(S)

	SECTION	NUMBER OF CONSUMERS					KWH PER MONTH	KW PEAK	LENGTH OF SECTION IN MILES	KW MILES	CONDUCTOR SIZE CU. EQUIV.	Ø / KV	WIRE FACTOR	% VOLTAGE DROP				
		SIGNED	POTENTIAL	ULTIMATE	BEYOND THIS SECTION	EQUIV. THIS SECTION								THIS SECTION CONCENTRATED LOAD	THIS SECTION DISTRIBUTED LOAD	THIS SECTION SUM	TOTAL	AT POINT
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1500 KWH	E to G	20		20	50	60	1500	380	4	1520	6	3 Ø	1.76		2.67			
	G to I	10		10	30	35	1500	250	5	1250	6	3 Ø	1.76		2.20			
	I to K	20		20	0	10	1500	90	4	360	6	V Ø	3.35		1.20	6.07		
2000 KWH	E to G	20		20	50	60	2000	520	4	2080	2	3 Ø	.838		1.74			
	G to I	10		10	30	35	2000	340	5	1700	6	3 Ø	1.76		3.00			
	I to K	20		20	0	10	2000	120	4	480	6	V Ø	3.35		1.61	6.35		
24000 KWH	E to G	20		20	50	60	2400	620	4	2480	2	3 Ø	.838		2.09			
	G to I	10		10	30	35	2400	410	5	2050	6	3 Ø	1.76		3.60			
	I to K	20		20	0	10	2400	130	4	520	6	V Ø	3.35		1.75	7.44		
3000 KWH	E to G	20		20	50	60	3000	760	4	3040	2	3 Ø	.838		2.60			
	G to I	10		10	30	35	3000	510	5	2550	2	3 Ø	.838		2.14			
	I to K	20		20	0	10	3000	175	4	700	6	V Ø	3.35		2.34	7.08		
	E to C	20		20	30	40	3000	575	4	2300	6	3 Ø	1.76		4.05			
	C to B	20		20	0	10	3000	175	4	700	6	3 Ø	1.76		1.23	5.28		

Harry R. Smith (REA Engineer): I wish to congratulate Mr. Hauck on his excellent paper and presentation. He has very effectively emphasized that system planning should look further than 10 years into the future. He has also pointed out the necessity of long range plans being kept up-to-date, and that planning for actual construction should not be too far in advance of the loads.

There has been considerable thought for some time in REA that each borrower should have long range plans that provide for more than 10 years load growth. The loans are for 35 years and the normal life expectancy of the materials and equipment used in the construction of a rural power system is considerably greater than 10 years. Good planning should assure a minimum of obsolescence necessitated by the removal of plant before it has seen effective service life.

From discussions with others interested in system planning and recent technical papers on this subject, it appears that long range plans should provide for loads that are expected to develop within the next 20 to 30 years. Also on the basis of these discussions it appears that planning should be primarily for the benefits that will result from good planning, and that the use of data from long range plans in support of loan applications should be of secondary importance. Plans made primarily to support a loan may not be the best from the planning standpoint, or in the borrower's best interests over a long period of time.

The following is a brief outline of the long range planning procedure which I believe would provide for good planning and would accomplish most of Mr. Hauck's objectives.

I. Long Range Planning Study And Report

(a) The borrower should furnish the engineer all relevant maps, load data, power supply data, records pertaining to the operations, maintenance and design of the present system and any other data which it might possess relating to the long range planning services to be performed by the engineer.

(b) The borrower's engineer should develop and present an overall long range plan in his report with alternate recommendations where appropriate. This report should include a brief discussion of the engineer's exploratory plans and include economic comparisons. It should also include a discussion and recommendation concerning continuity of service. He should specify only the major system improvement items.

(c) The long range plans should be on the basis of multiples of existing loading.

(1) This will normally be 3 to 6 times existing loading, the actual value should be established by the borrower with the recommendations of its engineer on the basis of past trends and factors that will influence future growth, including power requirement studies and field appraisal data.

(2) The long range loading should be similarly established by areas.

II. Annual Review Of Long Range Plans

(a) Each year for a period of 5 years after the report is approved by the borrower, the engineer should be required by his contract to review the long range plans and make whatever revisions are necessary.

(b) This should include a review of the basic data used in the studies and reports such as loading and future power sources.

III. Annual Work Plans

(a) During the development of the long range plans the engineer should analyze conditions of the existing system and develop immediate work plans for improvement items that should be installed the following 12 months. Each improvement item must be consistent with the long range plans but should not be called for prematurely.

(b) Each year for a period of 5 years after the report is approved by the borrower, the engineer should be required by his contract to analyze the borrower's operating records, the results of voltage and current investigations that have been made by the borrower and other applicable data and develop work plans for the system improvement items that should be installed during the next 12 months. These work plans must be consistent with the up-to-date long range plans, and should specify only the borrower's realistic needs for the immediate future.

IV. System Improvement Budget In Support Of Loan Applications

(a) Each Section 4 loan should be supported by an engineering study specifying the detailed system improvement items required to enable the system to provide adequate service to the total number of consumers with the kwh/mo/ consumer usage selected for the loan application. This system improvement budget must be based on the approved power requirement study and must be consistent with the borrower's long range plans.

(b) This engineering study will not be a requirement nor a part of the long range planning contract but will be a separate undertaking.

Mr. Hauck's 3000 kwh/mo/consumer as the design figure for the future system plan would not be in conflict with the above outline for most of the systems in his area. However, the use of this high figure for a large number of borrowers that are now averaging less than 200 kwh/member/mo would mean that the future plan would provide for over 15 times the borrower's existing loads. Such an extremely long range plan may not be practical.

The discussions in REA of the above outline have not disclosed any strong objections to such a planning procedure. Most questions have been concerned with the suggested limits, such as 6 times existing loading. These definitely deserve further consideration and study and I believe satisfactory answers can be found. You can be sure that REA will make some modifications in the present planning procedures that will provide for long range planning. In fact, Arch Loetterle, Roland Schlie and I have been assigned the task of developing a revised system planning procedure and

the necessary contract form. Following this meeting we plan to visit approximately seven engineering firms on our way back to the office to discuss this subject and obtain ideas, techniques and recommendations from these engineers that have actually been doing the planning work. Similar trips to a number of other engineering firms are also planned during the next two or three months.

In closing I'd like to ask that each of you send in any recommendations you have that would assist us in preparing a better procedure or guidelines for long range planning.

E. R. Brown and C. H. Kimzey (REA Power Requirements Section): Loans were made during the first 15 years of the Rural Electrification program on kwh estimates which were intended to represent at least the average consumption over the life of the loan. It was considered necessary from a legal point of view that loan funds be provided in any given loan for system capacity at least equivalent to the kwh levels on which loan feasibility was to be based. This concept did not permit any very tangible determination regarding when such levels of usage would be reached nor indicate when facilities to provide more capacity would need to be placed in service. Further, this concept was partially responsible at one time for a backlog of unadvanced loan funds approximating $650 million. Later, our procedures were changed to require 2, 5, and 10 year estimates and related system planning to the values indicated by these estimates to correspond to the immediate, intermediate and ultimate steps in system engineering studies. This change may have been an "over-simplification" of the earlier approach and may perhaps be a bit restrictive from a long-range planning point of view. However, let's not recommend or adopt any such inelastic approach as arbitrarily selecting 3000 kwh per month for design purposes. Rather, system expansion should always be flexible and tailored to fit the particular needs of the service area under consideration, as these needs may most accurately and precisely be determined.

The writer of this paper concurs that system planning must be of the very highest caliber. In any sound consideration of future capacity requirements and the economics involved, it behooves us to periodically review our methods and procedures for forecasting loads and planning future capacity. Our experience and research indicates that no single mathematical formula can accurately produce a valid estimate. Statistical correlations have also generally failed to produce a result upon which reasonable men will agree. The difficulty with statistical correlations is primarily attributable to the lack of precise measurement data for some of the independent variables. If such a formula could be developed, it would be through the use of a mass of data computed as a multiple correlation.

For the purpose of discussion, let us examine kwh consumption on the basis of Edison Electric Institute's figures for all farms east of the 100th meridian. This data indicates that in 1927 (the first year of available data) the average kwh consumption was 51. This average monthly kwh consumption increased somewhat erratically over the period to 1954 when the average was 270 kwh. An increase of 219 kwh in 27 years or an average increase of 8.1 kwh per month annually. At this rate of growth, an estimate of 3000 kwh per farm per month would not be achieved in over 300 years. The highest average farm consumption attained by REA systems in 1954 was in the State of Washington by a system energized in 1941 and averaging 985 kwh per month. Statistical analysis of the EEI data would indicate that the average kwh consumption is increasing by an increasing amount. Applying the least squares method of extrapolation ($YC = A + BX + CX^2$), these EEI data indicate an average of

840 kwh per month would be reached in 1975. This statistical approach is recognized only as one tool and accepted as such by professional people who have the responsibility of forecasting loads. A further analysis of these data would indicate various peculiarities with differing treatment of the data. For example, various periods from 1927 to 1954 indicate sharp increases in kwh consumption and also periods when these increases are at a lesser degree. In computing the data, employing different years of origin, the results can and may well be at considerable variance.

Although statistics and mathematics are one tool used in forecasting future loads, it is essential that the analysis include a judgment factor obtained by weighing all possible factors effecting the use of electricity. Let us examine again, the proposed 3000 kwh per month per farm and nonfarm consumer. This estimated kwh consumption would constitute an expenditure of almost $90 a month or over $1,000 a year for electricity alone. This expenditure for electrical energy would be extremely high as compared to gross farm income. An expenditure of $1,000 a year for electrical energy as compared to a percentage of the gross farm income for all states would be as follows:

% of Gross Farm Income	No. of States	% of all States
Less than 10	4	8.3
10 - 19	20	41.7
20 - 39	13	27.1
40 - 69	8	16.7
70 and over	3	6.2

The field of rural electrification is relatively new in our society and we have much to learn about its future. From a practical standpoint we must use every tool at our command to make load forecasting as accurate as possible. We recognize that technological developments in the future could weigh heavily on future loads. Under present conditions a saturation of present electrical appliances could be attained in a relatively short period of time. In addition to a complete saturation of electrical appliances, house heating, particularly in areas of low cost power, can greatly effect kwh usage. Even though we give considerable weight to house heating in the Bonneville and Tennessee valley areas we must recognize that when working with averages not all farms within these areas will have complete house heating by electricity. It appears reasonable to assume that houses with considerable age would not use electricity as the sole source of heat.

Our experience, studies and applied research in the field of rural electrification have demonstrated that many factors have an important bearing on use of electricity. The most important among these are: level of farm income, kind and size of specific farm enterprise, length of time with electric service, retail rates, competitive energy sources, adequacy of electric service and promotional effort. It has been found that farm income, kind and size of specific farm enterprise and length of time with electric service are the principal factors accounting for the variation in use of electricity on farms. The variation in average farm usage in different areas may be effected by other factors such as; the cost of power, competition from other energy sources and type of farming.

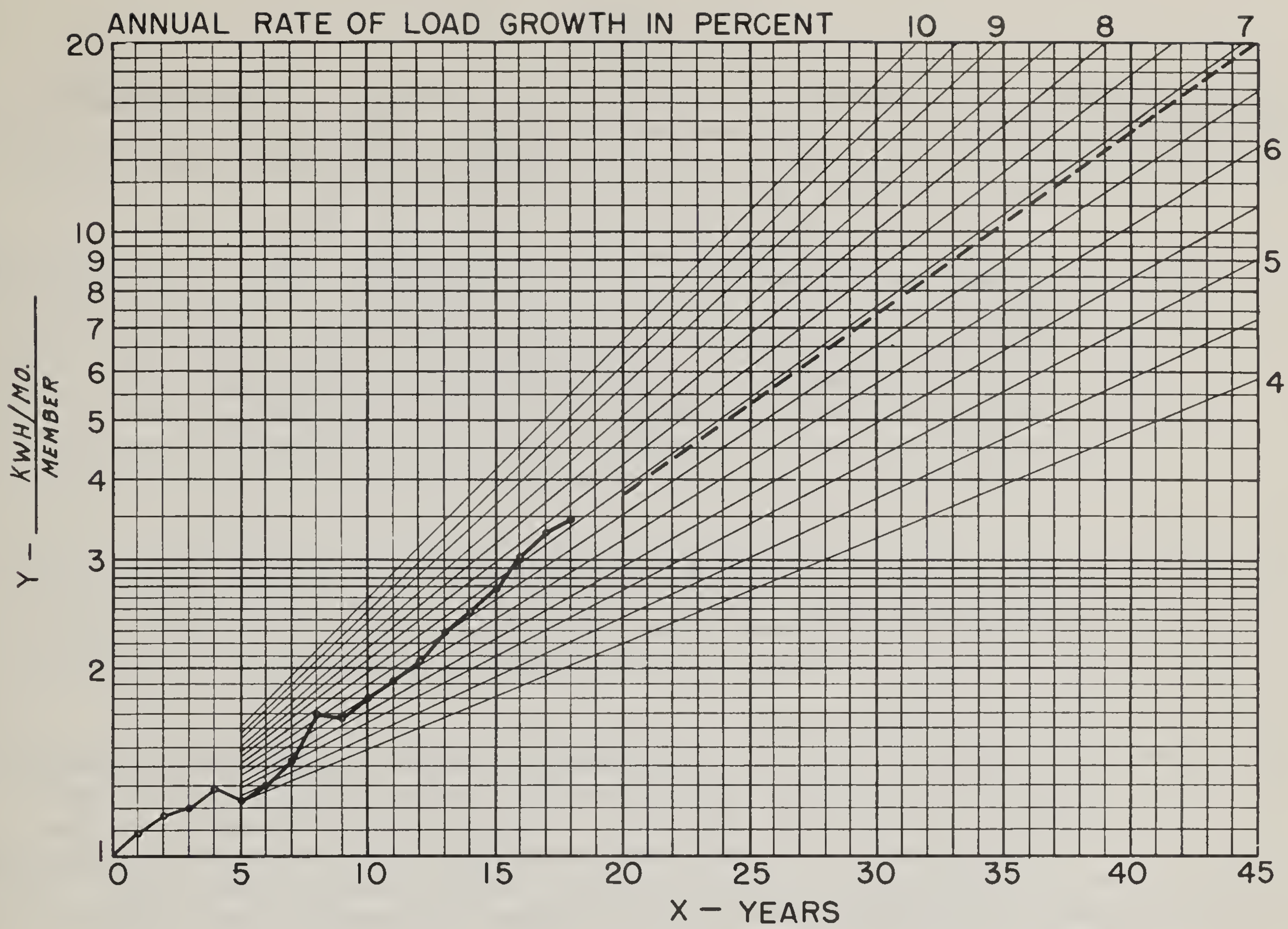
Other research organizations also find that income and cost of power very definitely affect the usage of electricity. It is extremely unrealistic to assume that the

cost of electric energy is a secondary consideration. Research studies from many sources prove quite conclusively that low retail rates have an encouraging influence on usage levels. Experience in the TVA area certainly substantiates these findings, as does the Federal Power Commission's "Typical Electric Bills." In areas where retail rates are higher, average kwh consumption is more closely correlated with income.

Our studies further indicate a correlation of electric energy use by types of farming. Dairy and poultry farms use more electricity than a general type of farm. Generally speaking, the larger the farm the more electricity it uses. The length of time a farm has received central station service is also a significant factor, the earlier farms receiving central station service start off at a low rate of consumption and gradually increase growth in later years. In dealing with averages the effect of dilution of new farms being connected is significant over a period of years. The factors mentioned are only a few of the elements that affect kwh usage. No single element in this group remains static for a given period of time. Even if it were possible to isolate any single variable, the others would be influenced by changes. Therefore, it is re-emphasized that future loads can not be forecasted strictly on a mathematical formula.

Doubtless, new applications of electricity are in the offing but the extent and scope of such applications are unknown. Also, the rate of increase in future usage on known applications may only be judged in large degree by past experience. We believe, and apparently the investor-owned utilities agree, that the soundest policy is to recognize technological changes as they take place and make adjustments when necessary to adequately serve the ever-increasing electrical needs of American farms and other rural establishments.

Roland W. Schlie (REA Engineer): System Planning includes a study of historical load data and the projection of future system loads. REA field engineers and area office engineers review and study numerous plots of historical and projected load data. These plots are normally included in all system studies. Standardization of these plots would facilitate more rapid and comprehensive review and study. Attached is a suggested form, the use of which would accomplish the desired standardization.



HISTORICAL LOAD DATA				PROJECTED LOAD DATA			
(1) CALENDER YEAR	(2) X CORDINATE	(3) LOAD / MEMBER	(4) Y CORDINATE	(5) X CORDINATE	(6) CALENDER YEAR	(7) Y CORDINATE	(8) LOAD / MEMBER
1935	0	72.7	1.0	20	1955	3.75	273
36	1	79.5	1.09	25	1960	5.35	389
37	2	84.5	1.16	30	1965	7.40	538
38	3	87.1	1.20	35	1970	10.30	749
39	4	93.9	1.29	40	1975	14.40	1047
40	5	89.4	1.23				
41	6	94.4	1.30				
42	7	103.2	1.42				
43	8	123.4	1.70				
44	9	121.7	1.67				
45	10	130.9	1.80				
46	11	139.1	1.91				
47	12	150.2	2.07				
48	13	166.4	2.29				
49	14	180.7	2.48				
50	15	194.6	2.68				
51	16	219.9	3.02				
52	17	238.6	3.28				
53	18	250.3	3.44				

LOAD PROJECTION FORM

SYSTEM *Northland* DATE *Dec. 1955*

ENGINEER *Joe J. Jones*

LOAD AREA *South Sub.*

Howard R. Zenier (Howard Zenier and Associates, Engineers): We have read with interest your treatise on System Improvement Planning. You have confronted a problem which has faced all electric systems and consulting engineers, one which becomes increasingly evident and important with each passing year.

In the past system planning has been based to a considerable extent on fundamentally erroneous assumptions. The major ones in that category have been:

1. Gross underestimates of load growth.
2. System Design based on an estimated 10 year period when system facilities are designed for 35 or more years of service.
3. Misapplication of the word "ultimate."

The study you have made points positively in the direction we need to go. Every system should have a distant horizon of load growth which it deems achievable at some time well into the future. System planning should then consider that horizon as the end product of system growth rather than any 10 year period. When that horizon comes too close, it is time to re-evaluate the system plans in the light of a new, more distant horizon.

Your analyses of energy consumption on a number of systems points out what many of the system managements have been saying frequently in the past few years. Load growth is following a rising curve and there is as yet no justification for the assumption of a leveling-off. We feel that one of R.E.A.'s most important functions should be that of helping the Borrowers to grow with or ahead of their loads. Load estimating based realistically upon the true rising rate should be an essential part of R.E.A.'s assistance to its borrowers.

By using a suitable "saturation" figure as the distant horizon, by realistically predicting the system growth, by divorcing overall system planning from a time schedule you are giving the Consulting Engineer some of the tools he must use to produce really valuable system plans.

We think you are on the right track here and are hopeful that this fresh outlook on long range planning will be reflected in other areas of relationship between R.E.A. and its borrowers.

W. J. Hauck: Each of the discussions confirmed the contention that system studies should include long range plans. The question that was not resolved however was whether the saturated system should be based on a selected minimum kwh level (such as 3000 kwh per month) or whether it should be determined individually for each system from an analysis of its current load trend.

This very question was given considerable study at the time the paper was prepared. The 3000 kwh level was chosen because of its practical aspects. There is near unanimity of agreement that the load will continue to grow. It was my further conviction (based on a review of many meter accounts) that where electric heating is considered the load will rise to at least 3000 kwh per month. Now, when making system studies for loads beyond 500 kwh per month the engineer will generally be faced with making one of the following choices:

1. whether to convert some of the line to 14.4-kv

2. whether to go to subtransmission

3. where to locate new substations or power supply points.

When applied to actual studies it was found that an ultimate load of 2000 kwh, for example, dictated a selection of one of the above that was not compatible with the layout required to serve the load when it grows to 3000 kwh. Further study showed that the necessary revisions would be very costly. By planning for at least 3000 kwh such costly revisions are avoided. On the other hand, actual studies made so far indicate that intermediate steps are no more costly when plahning for 3000 kwh than when planning for some lower usage.

There is no harm in knowing what to do should the load reach 3000 kwh, even though some may argue it will never happen. The purpose of advance planning is to save money and supply satisfactory service. As stated by Messrs. Davis, Moon and Tatum, "if a system cannot achieve the averages set by the advance plan, the recommendations of the plan beyond the applicable usage level will simply lie dormant."

Stated simply; when planning a system for loads beyond 500 kwh the engineer should include all the range of steps through 3000 kwh per month in order to avoid costly revisions should a lower selection be exceeded.

In regard to two other recommendations made in the discussion;

1. The idea of making the consulting engineer responsible, under the terms of his contract, for revising the system study periodically to keep pace with the actual load growth meets with wholehearted support. This weakness is very apparent in current procedures.

2. As the load grows the margin between generating costs or wholesale rates and retail rates becomes less. This makes rate analyses more and more mandatory as costly system improvements are made. However, whether such analyses should be made by the consulting engineer or by REA personnel should be given wholesome consideration before conclusions are reached.

STEP TYPE REGULATORS

Discussion And Author's Closure
Of Paper By R. E. Horn

Roland W. Schlie (REA Engineer, Washington, D. C.): The author's treatment of the subject is to be commended. Step type regulators are performing a very important role in rural distribution. Without accurate substation and line voltage control rural distribution would be at a distinct disadvantage.

Many of the application techniques of voltage regulators have been worked out for transmission systems. In recent years more articles pertaining to distribution application have appeared. However, much of the basic thinking still appears to stem from transmission system techniques. Application of regulators to rural distribution systems continues to increase. As a result, there is an ever-increasing need for the development of rural distribution system application techniques. I shall briefly discuss one example.

The concept of line-drop compensation is indeed an ingenious one. Voltage at a remote location is held at a predetermined level regardless of the load variations, source voltage variations or power factor variations. Needless to say, the transmission engineer would be at a loss without such a device. A distribution engineer looks at this device and marvels at its possibilities. With enthusiasm he begins to apply the concept to his system. His first disappointment comes when he discovers that he must consider not one remote location but several. The average rural substation supplies three to four feeders all of different length and many times of different conductor size. Perhaps he would then plan a regulator for each feeder. He again becomes disappointed due to cost limitations, short-circuit limitations and because of a feeder far more complex than the transmission line for which the application techniques have been developed. Many rural system operators tend to give up and not make any use of this ingenious device.

I believe the line-drop compensator to be a very useful device. In REA Bulletin 169-27, REA has given an explanation of the device and supplied a guide for application.

Manufacturers are to be commended for their efforts in explaining and illustrating the step type regulator. With specific reference to the line-drop compensator, much has been done to explain its application on transmission lines. Instruction booklets for pole-type regulators include these same instructions. Since the pole-type regulator is basically a distribution type regulator, I believe application information should take this into consideration.

The ever-increasing use of step regulators on rural distribution systems should stimulate the development of new application techniques.

R. E. Horn: Mr. Schlie has very ably pointed out the ramifications involved with present day controls on regulators. Manufacturers are aware of this problem and are attempting to eliminate it. As mentioned by Mr. Schlie more and more technical information is being made available. REA Bulletin 169-27 has played a very important role in explaining regulators and their application. Other methods are available that would make the setting of compensation on regulators easier but manufacturers have not found a way to make them available on an economic basis.

DISCUSSION OF CONFERENCE PAPERS

(Part Four)

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PRESENTED AT THE 1956 TECHNICAL CONFERENCE FOR
REA FIELD ENGINEERS, SAINT LOUIS, MISSOURI
JANUARY 16-20, 1956

U. S. DEPARTMENT OF AGRICULTURE

RURAL ELECTRIFICATION ADMINISTRATION

ABOUT THE CONFERENCE .... The purpose of the Annual Conference for REA Field Engineers is to provide a forum for the discussion of engineering matters concerned with rural electric systems. The objective is to make available to field engineers an opportunity to share views and experience with other engineers who have developed a high degree of experience and specialization in specific fields. Likewise, the objective is to provide the specialist engineer with an opportunity to share his views with those who are facing the practical daily engineering problems.

To assure freedom for the development of ideas which may serve to improve the engineering of rural electric systems, the authors of papers and discussions have been encouraged to explore new ideas and new techniques and to prepare papers which reflect their own engineering judgment and experience. Such an approach may develop ideas which deviate from industry practices and REA policies and procedures presently in effect. It should be recognized, however, that REA policies and procedures as set forth in REA bulletins are still applicable unless changed in the light of the ideas and experience which may result from such papers or discussions.

R G Zook

R. G. Zook
Assistant Administrator

FIBERGLASS CROSSARMS AND POLES

Discussion of Paper by W. R. Bailey

John F. Atkinson (REA Engineer, Washington, D. C.): The concept of using fiberglass reinforced plastic poles and crossarms is certainly a radical departure from existing practices. However, no one can deny that this new material offers a number of advantages that the electric utility industry cannot afford to overlook.

It is REA's practice to investigate every new development that shows promise of improving rural electrification. We first became aware of this fiberglass pole development last May when the Gar Wood people came to us to ask our cooperation in the further development and field testing of this new product.

We immediately recognized that fiberglass poles might be the solution to some of our difficult pole problems, such as pole fires due to industrial air contaminants. Flashover problems and pole fires are encountered almost daily in coastal areas because of salt spray contamination. Solution to the woodpecker problem was also considered as were termite and bacterial decay problems.

We put the Gar Wood people in touch with the Nueces Electric Cooperative at Robstown, Texas, and with two Florida cooperatives, the Lee County Electric Cooperative at Fort Myers, and the Florida Keys Electric Cooperative Association at Tavernier.

These three cooperatives have agreed to field test a limited number of fiberglass poles and crossarms in areas where wood poles and crossarms are failing rapidly due to the above mentioned causes. The McLean Engineering Company of Moultrie, Georgia is cooperating in some of these tests in behalf of the Florida Keys cooperative.

We understand that shipment of these experimental poles has been made, or is about to be made, and that field tests should be well under way by spring.

REA intends to cooperate in these tests by supplying the manufacturer with basic mechanical and electrical data, by close observation and by assisting in the evaluation of results obtained.

In addition, REA is sponsoring certain materials tests in cooperation with the Forest Products Laboratory, Forest Service, U. S. Department of Agriculture. Tests now under way include decay and termite resistance tests being conducted at the Harrison Experimental Forest at Saucier, Mississippi. Soil-block tests are being made at the Forest Products Laboratory at Madison, Wisconsin.

Other tests now being considered are aging tests with an evaluation of compressing and crushing properties, weatherometer tests, water absorption tests, and bending tests in the wet and dry condition.

Now a word about cost. The present cost of fiberglass poles and crossarms is considerably higher than conventional wood poles and arms. This is to be expected as this product is still in the early experimental stage. Cost must be reduced considerably to make this new material competitive.

There is every reason to believe that costs can be reduced appreciably through standardization of shapes and sizes, through mechanization of fabrication techniques and of course, through mass production. It appears that the greatest cost item in the production of these poles is in the fiberglass fabric itself. If poles and crossarms are to be mass produced at low cost, it seems that the production plant would necessarily have to include integral facilities for converting the basic raw materials into glass fibers. Then through a continuous and uninterrupted process, the glass fiber should be converted into yarns, rovings and fabrics which in turn could be fed directly into the pole making machinery.

The costs of the basic ingredients, sand, soda and the resins are certainly competitive with the basic cost of wood. The economy of the end product lies entirely in the manufacturing and processing costs.

MAINTENANCE LIABILITY

Discussion and Authors' Closure of Paper
By Clark Reid and Leean L. Huff

George K. Ditlow (REA Engineer, Washington, D. C.): It is evident that the authors have spent considerable thought and effort in evolving the procedure described in this paper and they are to be commended.

Any financial summary which does not include existing O&M backlog cannot reflect the actual worth of the physical plant. If the actual worth of the physical plant is not indicated in such a summary the actual financial position of the borrower will not be revealed. Because of this and other reasons I believe an approach such as this is desirable and necessary.

Up to this time the bulletins which REA has published on O&M have dealt primarily with particular items of equipment or categories and as a result are of a technical nature. Typical examples are the bulletins pertaining to Pole Inspection and Maintenance, Right-of-Way Clearing, Transformer Repair, Recloser Maintenance, Inspection and Maintenance Records, Outage Records, etc. Due to their relative importance we have been emphasizing the maintenance of Poles, reclosers and R/W during the past year and half and we plan to continue this practice. Along with this, however, we have recommended a systematic and well balanced overall inspection and maintenance program. I believe the procedure advocated by the authors will help provide the administrative framework for such a program.

One result of this procedure would be that it requires the borrower to evaluate his O&M program by units. This evaluation would include neglected, deferred, and future maintenance and could be accomplished without too much expense by a sample survey.

The comment is often heard that borrowers can obtain a reasonable idea of O&M to be done by summarizing the observations made by outside personnel as they ride along the lines in their daily work. Also that other utilities keep their plant in good condition without a so called special evaluation program. However, these utility systems are sufficiently old that their replacement and maintenance costs average out year after year. They can proceed on the basis of experience. Our borrowers cannot. The average weighted age of our lines in service is approximately nine and one half years. Furthermore our systems started with all new plant. As a result the biggest part of the maintenance program lies ahead. Since the amount of maintenance will be changing for the next several years it is particularly necessary that the borrowers evaluate their maintenance programs.

In accomplishing this evaluation the borrowers would be performing surveys comparable to the general inspection outlined in Bulletin 161-5R1 only in more detail in most cases. As more borrowers pursue this activity it poses the real possibility of less O&M inspection by REA personnel. This conforms with the general REA policy of the borrowers assuming more responsibility where qualified to do so.

This procedure, if effectively performed would require the keeping of good records. If they maintain good records for this program it would probably result in better records in other categories.

The statement of net worth (Figure 1) shows O&M costs, the normal future costs as well as the backlog. I question whether or not these so called normal O&M future expenditures should be shown on this statement and would appreciate the authors views on this matter.

One problem which has arisen in the past concerns nomenclature. Since the statement of net worth as set forth in Figure 1 is not intended to be a financial statement in the accounting sense but merely a working tool for management, it would seem appropriate to avoid the use of terms used in accounting such as assets, liabilities, net worth, etc. For instance actual worth might be used instead of net worth. Any suggestions along this line would be appreciated.

No policy or procedure is any more effective than the degree of acceptance which it receives by those who are responsible for its execution. If this procedure is to be effective the managers in particular must understand its objectives and advantages. How best to accomplish this is a real problem and suggestions will be welcomed.

I would appreciate any comments the authors may care to make on the following:

1. Appendix I lists quantities and costs for work units as developed by a Missouri borrower. How many other borrowers are keeping comparable data?

2. How many borrowers have had this procedure described to them? What was their reaction? Are any using it? Were any modifications indicated? Were any ideas or guidelines obtained for promoting this procedure?

Edward F. Wilson (Assistant Chief, REA's Electric Operations and Loans Division): There is no doubt that too many boards assume that a system is well maintained, when it is not. In such a situation, the board is misled into believing the system is financially more secure than the facts warrant. This is a problem which is real and important, and for which the authors propose a solution.

Unfortunately there are some new and unsolved problems created by the proposed solution. Since the authors forcibly argue only the advantages but do not state the disadvantages of their proposal, this discussion necessarily deals more with its disadvantages than with the advantages. However, I hope that further discussion will develop a more satisfactory solution to this important problem.

It is apparent that what the authors propose is unorthodox. The proposal is contrary to the provisions of the FPC Uniform System of Accounts. It contravenes accounting regulations of state regulatory bodies and procedures generally acceptable to the Internal Revenue Service. However, the proposal should be considered not on the grounds of mere orthodoxy and conformance to present day practice, but rather on whether the proposal is something which ought to be generally adopted.

Let us examine first the "statement of net worth." It is essentially a balance sheet. It differs from the conventional balance sheet in four major aspects:

1. The "amount" of total electric plant is included at the original cost figure. In the conventional balance sheet, the Reserves for Depreciation and Amortization are deducted from Total Electric Plant is determining the Total Assets. The effect of this change by the authors is to increase Total Assets by the amount of the Reserves for Depreciation and Amortization.

2. The funds for Deferred Operations and Deferred Maintenance are created and shown as separate items.

3. The liabilities are increased by the amounts of so-called Liabilities for Replacements, Accrued Operations, and Accrued Maintenance.

4. The Net Worth, is, in effect, adjusted by subtracting therefrom an amount equal to the Liabilities for Replacements, Accrued Operations and Accrued Maintenance and by adding thereto an amount equal to the Reserves for Depreciation and Amortization.

The authors are desirous of showing a specific Liability for Replacements and presumably considered this would duplicate a Reserve for Depreciation. Hence they disregarded the depreciation reserve.

Undoubtedly the Liability for Replacements tends to duplicate a Reserve for Depreciation. However, the one cannot be substituted for the other. REA Bulletin 103-2R1 points out that a 1% per year replacements fund is a minimum-level fund intended to take care of only those replacements not made as part of a system improvement program and up to only the original cost of the item being replaced. Depreciation, on the other hand, includes the loss in value due not only to ordinary wear and tear but due to obsolescence, inadequacy, and other factors. The best-known study of the causes of retirement of transmission and distribution plant shows that 71% of retirements are made because of inadequacy and obsolescence. This disregard of the loss in value due to inadequacy and obsolescence, in preparing a statement of net worth, seems to me to deserve further consideration.

The more basic element of the proposal, however, is related to the setting up of "accrued liability" for operations and maintenance work which was not accomplished. Even assuming that a reasonable estimate of the dollar cost or dollar amount of such work can be developed, the item is not a "liability," since the liabilities of a corporation include only obligations to outsiders. To call it something it is not, creates more misunderstanding rather than less. Presumably the authors do so because of the feeling that "net worth" is derived from the assets and liabilities.

Of course, it is correct that net worth should equal assets minus liabilities. It is equally correct that liabilities should equal assets minus net worth and that assets should equal the sum of liabilities plus net worth. The accounting records should be maintained to reflect changes in all three. There are accounting principles which govern the determination of all three. It is hardly accurate to assume that any one of the three elements of the equation is necessarily derived from the other two.

In the 3rd and 4th paragraphs the authors also and correctly point out that "changes in the net worth over a period of time is a measure of the progress being made." They also refer to "condition of the business," "actual status of the business," and finally build up to "true financial condition of the system." While the authors do not specifically so state, they imply that if net worth and unrestricted general funds are both reduced by the amount of "accrued maintenance" the "true financial condition of the system" will be shown. While it is difficult to analyze this proposition in the absence of a definition of "true financial condition," it is doubtful that any such simple adjustment of net worth would show either the true financial condition or even the "actual status" of a going concern. It seems to me that the authors have, in this respect, set for themselves an impossible task.

In general, accounting records and reports are so maintained as to show what actually happened, not to show what might have happened. As I see it, with respect to maintenance and operating expenses ordinarily shown under Accounts 761 and 768 in the REA Uniform System of Accounts, the authors propose that the net worth should reflect not what was done, but what might have been done or what someone thinks should have been done. This is not a brand-new idea. However, previous proponents generally suggested that such ersatz expenses would be shown not only on the balance sheet but would also be shown as expenses on the profit and loss statements. This manipulation has the effect of "normalizing" expenses and in some circumstances may have some value. However, it also has the effect of overstating one year's expenses and understating another year's expenses, when compared with actual expenses.

However, this principle of basing the accounting records on "what might have been" or "what should have been" cannot logically be extended in the accounting system. For example, someone might have thought that a certain utility should have spent $5,000 in the previous year on power use work, when actually it spent nothing on power use. Should that $5,000 be shown as an additional liability? Assuming that the additional expenditure would have resulted in some increase in revenue, should that "might have been" increase in revenue also be shown? No, for once the net worth becomes a reflection of what might have been rather than what actually happened, the records reflect a hypothetical situation and not the results of the actual operations.

It seems necessary to me, in order to handle the problem posed by the authors, to break it up into two parts: that kind of work which is deferred because sound management judgment dictates that it is better to defer it than not; and that kind of work which should have been done but was not. For convenience, let us describe the former as deferred and the latter as neglected.

Any management should have a budget covering future operations. The budget should include the cost of doing all the work that is proposed to be done during the budgeted period. In any given case, this might include both deferred and neglected maintenance. With respect to the balance sheet or the Statement of Net Worth, which refers to past operations, it seems a contradiction in terms to say that maintenance work which was deferred because it should not be done should be charged off as an expense or reduction of net worth chargeable to past operations.

If a manager, in preparing supplemental reports to the board of directors concerning the accumulated margins, were to estimate the cost of neglected maintenance work and show what the margins would be had the work been performed, such a report would reflect the estimate without distorting the picture of what actually happened. However, in any such report it is essential that we not use terminology which is based on meanings that conflict with accepted practices. "Net worth" to be useful to management, must have a constant meaning. Unless all of us - engineers, accountants, etc. - adhere to generally accepted definitions of technical terms, we cannot communicate intelligently with others in our profession.

I would also question the desirability of using the formula proposed for determining a liability for accrued operations. Let us assume that for a particular system the management was in the practice of doing 1/5 of its clearing each year on a 5-year rotating program and that this is a sound program. Let us say that the annual cost of this clearing program was $25,000. Under standard accounting practices this amount of work would be done and charged off as an expense each year. Under the proposal, an amount equal to the sum of 100% plus 80% plus 60% plus 40% plus 20% times $25,000, or $75,000, would be set up as an accrued liability. Actually, sound

management decisions had demonstrated that all of the clearing was being done as it was needed. Why then should three future years' clearing be charged as an expense against prior years' operations instead of to the years in which the expenditures were incurred?

The development of work units and unit costs is an aspect of the paper to which I wish the authors had given more attention. A good case could be made out for the proposition that of all the major segments of industry, the electric utility industry has made the least progress in the development of work units and unit costs. There are some notable exceptions, as in production costs, and the cost of money, but on the whole unit costs are more to be noticed by their absence than by their use.

There are of course some obvious reasons why this is likely to be so. On the whole, individual maintenance and operations activities are not performed repetitively. Even when an individual operation is performed frequently, the conditions often vary so greatly from time to time that the number of units constituting a "fair day's work" varies so much as to rob the standard of any validity in a particular instance. The work generally must be done under conditions not conducive to refined record keeping. Unless and until some practical way can be developed to separate the transportation time, and other direct and indirect costs over which the individual worker has little or no control, from the direct labor time for which management desires a standard by which to measure efficiency, the unit costs seem comparatively artificial and of little practical value.

Perhaps this complexity is illustrated by what appears to be a discrepancy in the paper: on Page 4 the authors say, "the work unit of re-clearing should be one span of pole line." However, in Figure 2 and Appendix I the authors use a series of units. The development of work units is difficult, but essential to the development of any practical records system, and deserves further attention.

I would like to repeat that the accomplishment of the basic objective of the authors will be of great value to management, and any step in that direction is worthwhile. The authors have taken such a step, and the study is to be commended on that basis.

Clark Reid and L. L. Huff: The REA program is young in the electrical industry and this imposes special engineering problems which must be solved. The plant of the average cooperative is new and has not reached the age where operations and maintenance requirements are fairly constant. Until such time that operations and maintenance activities reach a stable state, management is confronted with the problem of evaluating the condition which exists at any time as well as the trends and rate of change. The purpose of this paper is to provide the cooperatives with a management tool or technique which will furnish this information during such interim period. The usual utility techniques will suffice after the cooperatives reach an age at which the stable conditions exist.

We want it clearly understood that the suggested procedure is not an accounting setup and does not replace, modify, or affect in any manner the established accounting methods. Since this is the case, we have not been concerned with accounting orthodoxy or nomenclature. We have used the words "assets", "liabilities", and "net worth" because they transmit to the average person the exact thought we desired to convey. We realized the accounting profession uses these words in a narrower sense. However, our desired audience is members of cooperatives' boards who do not have the accountants' bias to the use of these specific words.

We thought the background was amply set out on the first page of the paper and objectively summarized in the first paragraph on page 2, but one of the discussions would indicate that this was not fully accomplished. Therefore, we hope the above will correct the misunderstandings.

Both discussions raised a question regarding the propriety of including the "normal future" costs as well as the "back-log" costs in the liability estimates. Obviously the matter of "normal future" costs is raised by the method suggested in the paper for estimating the liability for right-of-way reclearing and routine meter servicing since the liability for all other items discussed is determined from field observations. The ideal condition for a right-of-way would be to have the brush all cut to ground level. The practical method is to cut it on a recurring cycle. Based on a recurring cycle of five years the weighted age of the brush is three years. Therefore, the maintenance liability is three times the annual cost, or $75,000.00 as computed by Mr. Wilson.

Mr. Ditlow, in his discussion, concluded with two points consisting of several related questions. This matter has been discussed casually with several managers. The reaction in most cases was favorable, but in only one instance was the procedure installed. The data in Figure 2 and Appendix I were obtained from this cooperative. No effort has been made to promote this procedure because it does not represent approved REA policy.

LOAD TRENDS ON RURAL LINES AND METHODS OF RECORDING AND CALCULATING DATA

Discussion and Author's Closure of Paper by John Case

Roland W. Schlie and Clifford J. Waldron (REA Engineers, Washington, D. C.): The author's statement that "the only possible way to determine load is to actually measure it" is certainly true. Also, without a knowledge of system load, management is hampered in its own construction work and operation. We believe that REA Bulletin 161-8 is a suitable guide to conduct a practical, economical investigation of system loads.

The system illustrated in Figure 2 is not adaptable to many combinations of switching arrangements for shifting loads. The following table presents the only possible combinations of switching positions that would not cause appreciably more than 1.5 times full load on any station, with all sections energized. The length of period with this much overload should be known. The table shows that S-2 and S-3 would always be required to supply at least the sections adjacent to them.

LOAD SHIFTING

COMPARISON OF NORMAL WITH SHORT EMERGENCY LOADS

Condition	Switch Position						Station Load					
							S1		S2		S3	
	S1	SW1	S2	SW2	S3	SW3	amp	%	amp	%	amp	%
Normal	C	O	C	O	C	C	32	92	60	86	120	115
E1	O	C	C	O	C	C	0	0	60	86	152	146
E2	C	O	C	C	C	O	32	92	100	143	80	77

With normal conditions where S-3 supplies two sections, there is a 15% overload, making it advisable to keep a fairly close check for occurrence of sustained higher values.

The American Standard Guide for Loading Oil-immersed Distribution and Power Transformers (C-57.32-1948) should prove of considerable value in determining maximum station load.

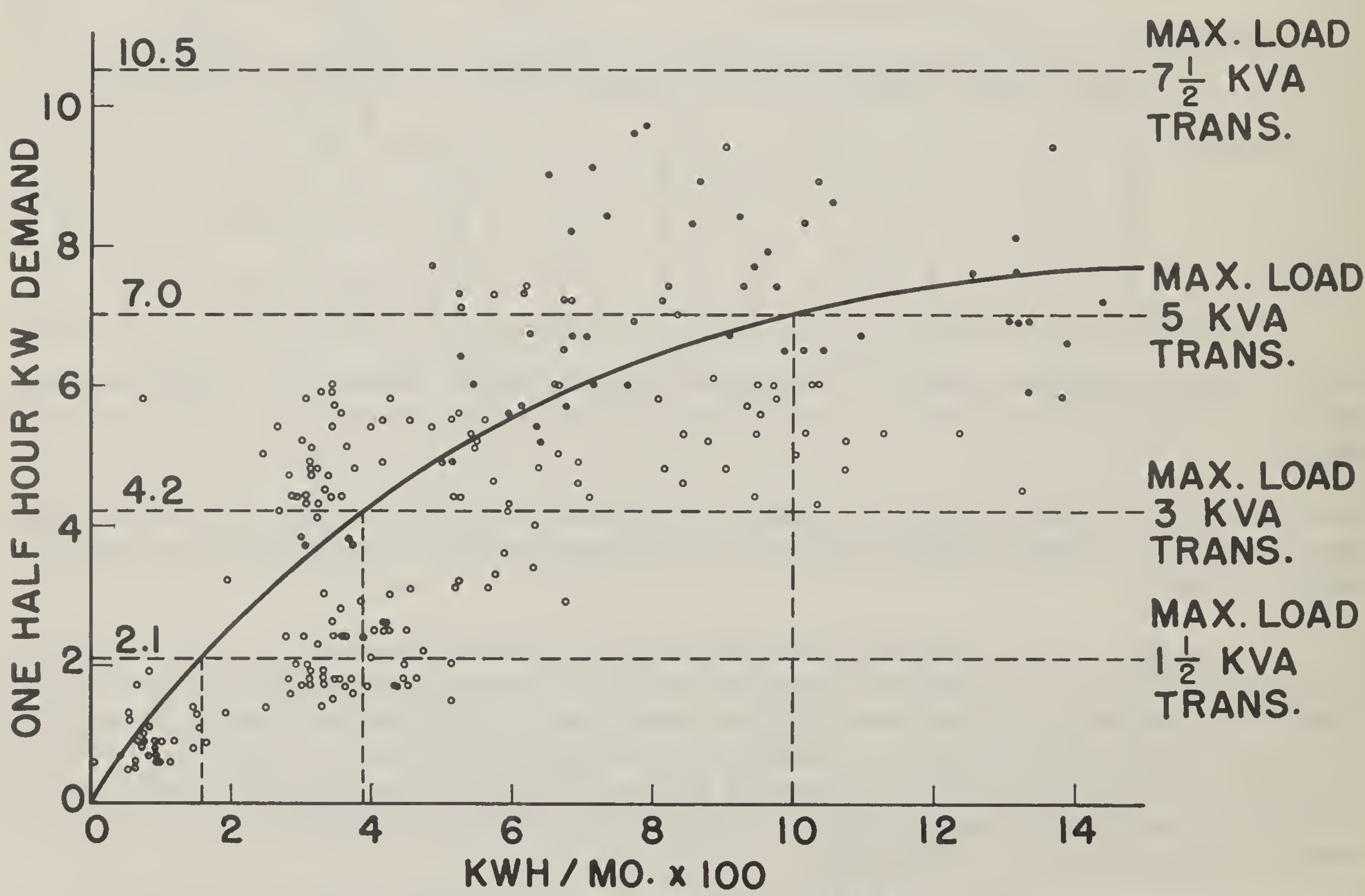
It is essential that a program for system improvements be based on trends indicated by past experience inasmuch as there is no way of predicting deviation from future trends. Knowledge of conditions at key locations in the system should be available as a check upon predictions, to avoid over or under-building. Whether 80 or 90 percent of full capacity of the system is the point at which system improvement should be begun would depend upon the observed rate of increase of demand, as well as the other factors stated in the paper.

A properly designed circuit should not have voltage problems when the demand approaches the load limit. The problem would occur when peaks of appreciable

duration exceed the load limit. Generally these peaks are the first symptoms of inadequate facilities. As described in REA Bulletin 161-7, simultaneous voltage charts for a 24-hour period can be taken at the substation and at the end of primary lines in question. Such charts will indicate present voltage drop. Estimates of future voltage drop can be obtained by the use of these charts, maximum current measured during the 24-hour period, and estimated future ampere demand.

The maximum recommended one-half hour integrated demand for a distribution transformer serving one consumer is 140 percent of the nameplate rating. The 140 percent value is based on voltage flicker considerations in minimum primary voltage coincident with maximum consumer load. Rural consumer loads not exceeding a one-half hour integrated demand equal to 140 percent of the transformer nameplate rating will rarely thermally overload the transformer. Therefore thermal limitations rarely determine loading limits for distribution transformers serving one consumer.

The author's comments appear to oversimplify the problem of transformer loading. The complexity of the problem is partly a matter of economics and partly a problem of consumer load characteristics. It is doubtful that extensive transformer measurements can be justified economically. Consumer load characteristics indicate extreme variation in demand compared with a specified consumption. The attached plot of Individual Consumer Demands and One-half Hour KW Demand illustrates these variations. Reference is made to a recently circulated Staff Report entitled "The Distribution Transformer Loading Problem."



INDIVIDUAL CONSUMER DEMANDS

John E. Case: One of the duties of every good operating man is to watch the regulation on his lines and to correct any such condition which arises before this regulation becomes excessive. He must know that the load limit is that point where the regulation becomes greater than the accepted maximum or seven percent. According to regulation calculations in the system study the maximum seven percent is caused by a certain load whose current can be determined easily. Now, inasmuch as this current is the maximum we can stand without excessive regulation it can be seen that the operating man will make arrangements for corrective measures as he approaches reasonably close to this current value. It should be his ideal never to actually get to that point.

It is agreed that extensive transformer measurements cannot be justified economically; however there has not been a need for extensive transformer measurements. Transformer measurements are generally used in the case of individual voltage complaints where a voltage chart tells us there is a low voltage condition. The transformer measurement either localizes the trouble to the transformer capacity or generalizes it to the line capacity. The interpretation of the transformer measurement tells us which.

DISCUSSION OF QUESTIONNAIRE

On the closing day of the conference an evaluation questionnaire was completed by forty-nine of the participants. The following is a summary of the replies.

1. In your opinion, do the benefits gained from technical training meetings of this type justify the time spent in attendance? Give reasons for your reply.

   Field: Yes (36); No (0). Washington: Yes (13); No (0).

   Reasons: The predominant reason given by both field and Washington was that the conference provided an opportunity to discuss and exchange theoretical and practical engineering ideas. In addition, the field also frequently mentioned that it provided an opportunity to acquire information on subjects related to their work which was not otherwise available and that it provided an opportunity to learn methods used by other engineers and new developments from Washington and the industry in general.

2. How did you feel about this meeting? (Check)

Field :	Good (18)	Very Good (2)	Excellent (16)
Washington:	(3)	(0)	(9)

3. What were the strong points?

   Predominant comment from both field and Washington related to the good selection of topics on the program, the field trips, and discussions by non-REA personnel. Field also commented frequently on the excellence of the group participation and the quality of the presentations. Other comments: "field participation on the program;" "organization of the meetings;" "well prepared papers and sufficient time for prior review."

4. What were the weak points?

   There was not much consensus among field or Washington on the weak points. Two or three persons each made the following points: (Field) "reading by others instead of presentation by author;" "insufficient time for discussion;" "formal written discussions rather than open discussion." (Washington) "insufficient participation from the floor;" "not enough time for important discussions."

5. a. From which topics did you derive the most benefit?

   Allowing ten points for each time subject was listed as first choice, five points for each time subject was listed as second choice, and two points for each time a subject was listed as third choice, the following is the number of points scored for the top three selections (figure in parenthesis indicates the number of times a subject was listed as first choice): (Field) System Improvement Planning (11) 171 points; Economic Design of Primary Lines for Rural Distribution Systems (10) 118 points; Service to Large Motor Loads (3) 73 points. (Washington) System Improvement Planning (9) 100 points; Economic Design of Primary Lines for Rural Distribution Systems (2) 24 points; Service to Large Motor Loads (1) 21 points.

The predominant reason given for selecting each of the three topics listed related to the importance of the problem to borrowers and the fact that they are problems which field engineers are frequently called upon to discuss.

6. a. Did you read the program material which was sent to you prior to the conference?

Field :	All	(13)	Some	(23)	None	(0)
Washington:		(3)		(10)		(0)

b. Do you think such material should be distributed prior to the next meeting?

Field :	Yes	(36)	No	(0)
Washington:		(13)		(0)

c. Suggest anything else that might be done ahead of the meeting to prepare the group.

There was no consensus in the answers to this question.

7. What suggestions do you have for improving methods of presentation.

A predominant thought expressed by both field and Washington in answer to this question related to the apportionment of time to the principal speaker, the formal discussions, and open discussion from the floor. Although there was not complete agreement, preference tended in the direction of more time for open discussion from the floor. Another frequent comment was: "more and better visual aids." Field representatives also said "eliminate discussions of technical papers by those not qualified."

8. List, in order of preference, three cities in which you would like to have the next meeting held:

Using the point system described in question 5 above, the following is the result: (Field) New Orleans (7) 124 points; Dallas (6) 86 points; St. Louis (5) 68 points. (Washington) St. Louis (4) 44 points; New Orleans (2) 27 points; Pittsburg (2) 26 points. (Combined) New Orleans (9) 151 points; St. Louis (9) 112 points; Dallas (6) 88 points.

9. List the specific subjects which you would recommend for treatment at future meetings.

Topics listed by three or more persons are given below. Figures indicate the number of times the subject was listed. Field: Operations and Maintenance (9) Nuclear Power (12) System Studies (9) New Developments in Equipment or Methods (6) Economic System Design (5) Rate Theory and Application (3). Washington: System Planning (7) Nuclear Power (4).

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